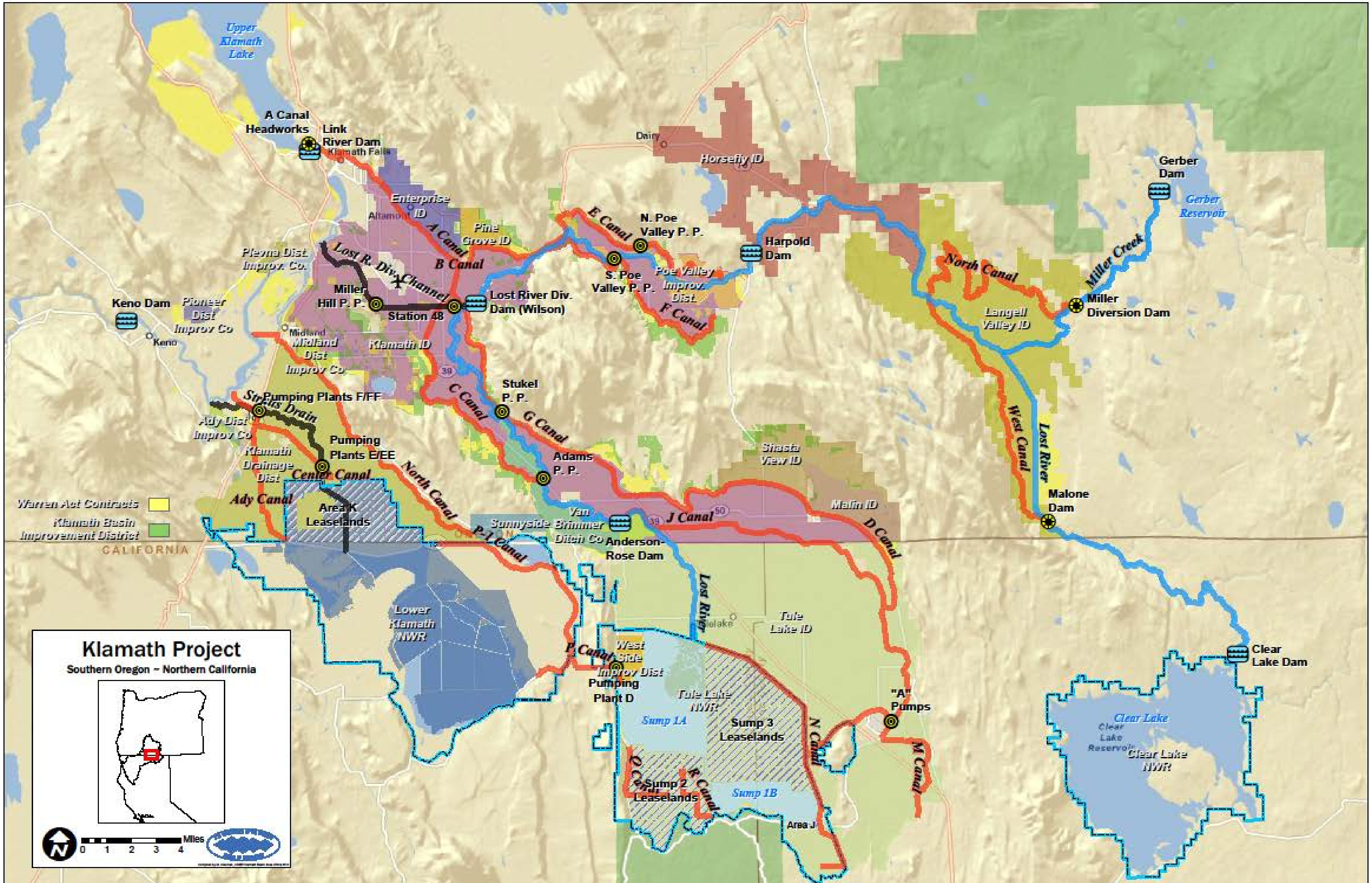
Appendix 1A: Project Map


Klamath Project
Southern Oregon ~ Northern California
Upper Klamath Lake
A Canal Headworks
Link River Dam
Klamath Falls
Enterprise ID
Altamont
Pine Grove ID
A Canal
B Canal
Plevna Dist. Improv. Co.
Lost R. Div. Channel
Miller Hill P. P.
Station 48
Lost River Div. Dam (Wilson)
Keno Dam
Keno
Pioneer Dist Improv Co
Midland
Midland Dist Improv Co
Klamath ID
Stukel P. P.
C Canal
G Canal
Straits Drain
Pumping Plants F/FF
Ady Dist Improv Co
Klamath Drainage Dist
Pumping Plants E/EE
Center Canal
Ady Canal
Area K Leaselands
North Canal
Adams P. P.
Warren Act Contracts
Klamath Basin Improvement District
CALIFORNIA
Sunnyside
Van Brimmer Ditch Co
P-1 Canal
Anderson-Rose Dam
J Canal
D Canal
Malin ID
Shasta View ID
Dairy
Horsefly ID
E Canal
N. Poe Valley P. P.
S. Poe Valley P. P.
Poe Valley Improv. Dist.
F Canal
Harpold Dam
North Canal
Langell Valley ID
Miller Creek
Miller Diversion Dam
Gerber Dam
Gerber Reservoir
West Canal
Lost River
Malone Dam
Clear Lake Dam
Clear Lake
Clear Lake Reservoir
Clear Lake NWR
Lower Klamath NWR
Tule Lake ID
Tulelake
P Canal
West Side Improv Dist
Pumping Plant D
Tule Lake NWR
Sump 1A
Sump 3 Leaselands
N Canal
"A" Pumps
M Canal
Q Canal
Sump 2 Leaselands
R Canal
Sump 1B
Area J
Miles
0 1 2 3 4

Appendix 1B: Species List Correspondence

United States Department of the Interior

BUREAU OF RECLAMATION
Mid-Pacific Region
Klamath Basin Area Office
6600 Washburn Way
Klamath Falls, OR 97603-9365

IN REPLY REFER TO:
KO-300 (JLand)
ENV-7.00

SEP 19 2011

MEMORANDUM

To: Field Supervisor, U.S. Fish and Wildlife Service
Attn: Ms. Laurie Sada

From: Jason Phillips
Area Manager

Subject: Request for Concurrence Regarding Species and Critical Habitat Located Within the Action Area of the Informal Consultation on the Operations of the Klamath Project

Dear ~~Ms. Sada:~~ Laurie

As you are aware, the Bureau of Reclamation is currently in the process of informally consulting on the effects of possible changes to Klamath Project operations on any listed or proposed species or designated or proposed critical habitat that may be present in the action area under the Endangered Species Act (50 CFR 402. 12(c)).

The action area includes the area within the boundaries of the Klamath Project, located in southern Oregon and northern California, including the Klamath River.

Our data indicates that the endangered Lost River sucker *(Deltistes luxatus,)* shortnose sucker *(Chasmistes brevirostris)*, and Applegate's milk-vetch *(Astragalus applegatei)* are located within the action area. If you concur with this finding, or if there are other species or designated critical habitat which we have not included that could be affected by the proposed action, please respond to us by October 14, 2011, with your concurrence or an updated species and critical habitat list.

If you have any questions, please contact Jennie Land at 541-880-2572, or via e-mail at jland@usbr.gov.

cc: Ron Larson
Trisha Roninger
Irma Lagomarsino

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Klamath Falls Fish and Wildlife Office
1936 California Avenue
Klamath Falls, Oregon 97601
(541) 885-8481 FAX (541)885-7837

In Reply Refer To:
81450-11-SL-0057

OCT 17 2011

Memorandum

Jason

To: Area Manager, Klamath Basin Area Office, U.S. Bureau of Reclamation, Klamath Falls, Oregon

From: Field Supervisor, Klamath Falls Fish & Wildlife Office
Klamath Falls, Oregon Laurie R Sada

Subject: List of Endangered, Threatened, or Candidate Species Known or Potentially Occurring in the Klamath Project Action Area

This responds to your September 19, 2011, memorandum requesting concurrence on the list of endangered, threatened, proposed, and candidate species and their designated and proposed critical habitat that are likely to be present in the subject action area. We reviewed your list and determined that two additional species or their critical habitat are present or potentially present in the subject action area. To assist you in this process, we have developed Table 1 which is a complete list of the species and critical habitat that are likely to be in the action area. Please note that bull trout critical habitat was recently designated for tributaries of Agency Lake. See the attached map and visit the following website for additional information:

http://www.fws.gov/pacific/bulltrout/pdf/Justification%20Docs/BTChapter9.pdf.

If you have any questions or need additional information, please contact Ron Larson of my staff at (541) 885-2506.

Official File Copy
Received

Date Received: 10/18/2011			
Date of Letter: 10/17/2011			
Control Number: 11078812			
File Code: ENV-7.00			
Folder I.D.: 1151708			
Project: 12			
Code	Initial	Date	Action
300JL			
300JH			

NOTICE: If you detach original enclosures to send with the out-going response letter or to keep for your files, please sign and date

Sign ______________ Date______________

Table 1. Federally endangered, threatened, proposed, and candidate species and critical habitat under Fish and Wildlife Service jurisdiction documented present or potentially present in the action area.

Species	Scientific Name	Status	Critical Habitat Status	Documented Presence in the Action Area	Possible Presence based on Habitat
PLANTS					
Applegate's milk-vetch	*Astragalus applegatei*	E	None	Yes, is documented adjacent to the shoreline of Keno Reservoir/Lake Ewauna	Yes, potential habitat is present between Keno and the Link River adjacent to the shoreline of Keno Reservoir/Lake Ewauna
FISHES					
Shortnose sucker	*Chasmistes brevirostris*	E	Proposed	Yes, is documented in Gerber Reservoir, Clear Lake, Lost River, Tule Lake, Keno Reservoir, and Upper Lake and major tributaries	Yes, habitat is widespread in upper basin in Upper Klamath Lake tributaries and could be present seasonally in Project canals
Lost River sucker	*Deltistes luxatus*	E	Proposed	Yes, is documented in Clear Lake, Lost River, Tule Lake, Keno Reservoir, and Upper Lake and major tributaries	Yes, habitat is widespread in upper basin in Upper Klamath Lake tributaries and could be present seasonally in Project canals
Bull trout	*Salvelinus confluentus*	T	Designated (see attached map)	Yes, is documented in some tributaries to Upper Klamath Lake	Yes, habitat is present in upper reaches of some Upper Klamath Lake tributaries
AMPHIBIANS					
Oregon spotted frog	*Rana pretiosa*	C	None	Yes, known from wetlands above Upper Klamath Lake and elsewhere in the upper basin	Yes, habitat is present near Upper Klamath Lake and tributaries

United States Department of the Interior

BUREAU OF RECLAMATION
Mid-Pacific Region
Klamath Basin Area Office
6600 Washburn Way
Klamath Falls, OR 97603-9365

IN REPLY REFER TO:

KO-300 (KHiatt)
ENV-7.00

OCT 12 2012

MEMORANDUM

To: Field Supervisor, U.S. Fish and Wildlife Service
Attn: Ms. Laurie Sada

From: for Jason Phillips Terri Reaves Gilmore
Area Manager

Subject: Request for Verification of Current Accuracy of Species and Critical Habitat Located Within the Action Area of the Informal Consultation on the Operations of the Klamath Project

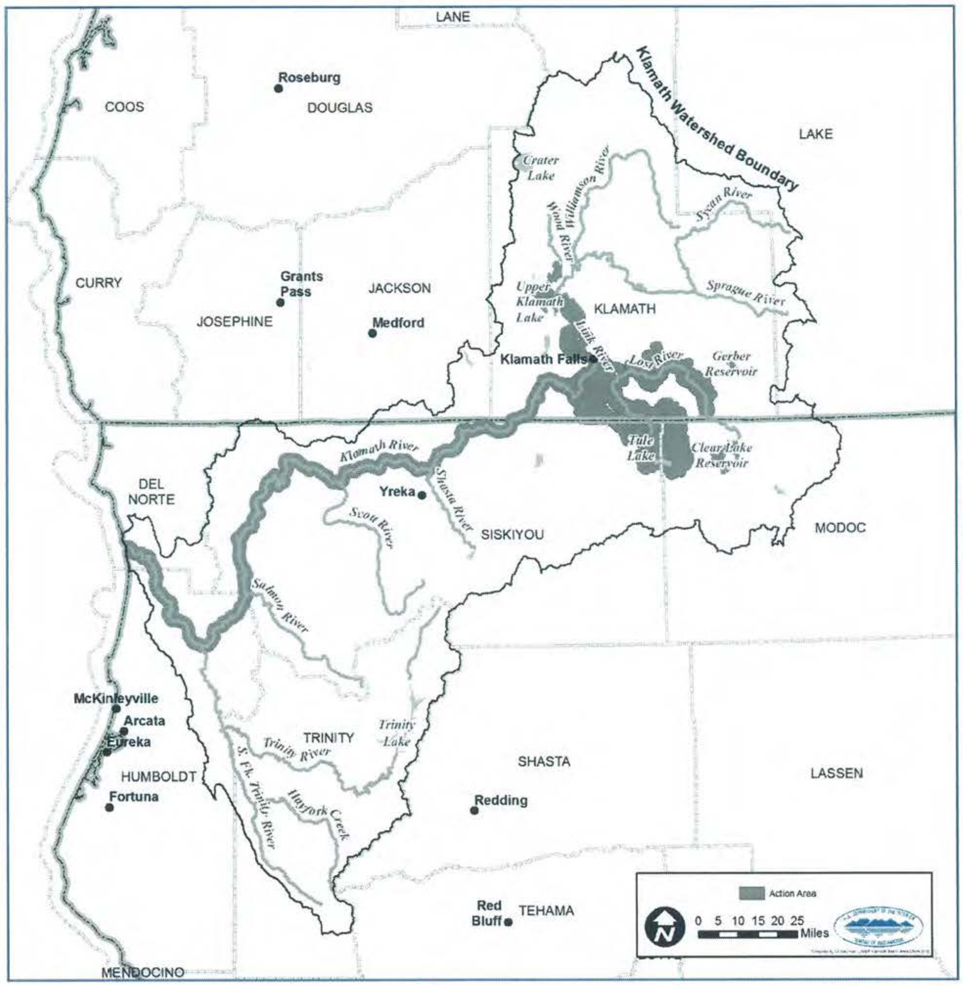
As you are aware, the Bureau of Reclamation is currently in the process of informally consulting on the effects of modifications to Klamath Project operations on any listed or proposed species or designated or proposed critical habitat that may be present in the action area under the Endangered Species Act (50 CFR 402. 12(c)).

The action area extends from Upper Klamath Lake, in south central Oregon, and Gerber Reservoir and Clear Lake Reservoir in the Lost River drainage in southern Oregon and northern California, to approximately 240 miles downstream to the outfall of the Klamath River at the Pacific Ocean, near Klamath, California (see attached map).

On October 17, 2011, the U.S. Fish and Wildlife Service provided the species information outlined in Table 1 as a complete list of the species and critical habitat that are likely to be in the action area. The initial correspondence associated with obtaining a species list was performed in the preliminary phases of informal consultation and preparation of a draft Biological Assessment had just begun. As such, Reclamation is seeking to verify the current accuracy of the species list (50 CFR 402.12(e)).

If this list is still accurate, please respond as soon as possible with your concurrence with the species list in Table 1 or provide additional information if there are other species or critical habitat which we have not included that could be affected by the proposed action.

If you have any questions, please contact Kristen Hiatt at 541-880-2577, or via e-mail at khiatt@usbr.gov.



Map of the Action Area. *Source: Bureau of Reclamation 2012.*

Table 1. Federally endangered, threatened, proposed, and candidate species and critical habitat that may occur within the action area.

Species	Scientific Name	Status	Critical Habitat Status
PLANTS			
Applegate's Milk-vetch	*Astalgalus applegatei*	Endangered	None
FISHES			
Shortnose sucker	*Chasmistes brevirostris*	Endangered	Proposed
Lost River sucker	*Deltistes luxatus*	Threatened	Proposed
Bull trout	*Salvelinus confluentus*	Threatened	Designated
AMPHIBIANS			
Oregon spotted frog	*Ranae pretiosa*	Candidate	None

Attachment

cc: Ron Larson
Trisha Roninger
Irma Lagomarsino

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Klamath Falls Fish and Wildlife Office
1936 California Avenue
Klamath Falls, Oregon 97601
(541) 885-8481 FAX (541)885-7837

In Reply Refer To:
08EKLA00-2013-SL-0003

NOV 1 2012

Memorandum

To: Area Manager, U.S. Bureau of Reclamation
Klamath Falls, Oregon

From: Field Supervisor, Klamath Falls Fish & Wildlife Office
Klamath Falls, Oregon

Subject: List of Endangered, Threatened, or Candidate Species Known or Potentially Occurring in the Klamath Project Action Area

This responds to your October 12, 2012, memorandum requesting verification of listed species and critical habitat known or potentially occurring in the Klamath Project action area. The Bureau of Reclamation intends to formally consult with the U.S. Fish and Wildlife Service under section 7 of the Endangered Species Act and needs to have the current species list to complete their biological assessment. The information on the listing and critical habitat status of species that was presented in Table 1 of your memorandum is currently accurate. However, there will be one change that you should be aware of. We anticipate that critical habitat will be designated for the Lost River sucker and shortnose sucker by the end of 2012.

Thank you for your efforts to conserve federally-listed species. If you have any questions about this document, please contact Ron Larson of my staff at (541) 885-2506.

Official File Copy Received			
Date Received: 11-5-12			
Date of Letter: 11-1-12			
Control Number: 12068466			
File Code: ENV-7.00			
Folder I.D.: 1198308			
Project: 12			
Code	Initial	Date	Action

7-1596B (9-89)
Bureau of Reclamation

United States Department of the Interior

BUREAU OF RECLAMATION
Mid-Pacific Region
Klamath Basin Area Office
6600 Washburn Way
Klamath Falls, OR 97603-9365

OFFICIAL FILE COPY		
DATE	SURNAME	CODE
5/1/12	[illegible]	KO-100
5/1/12	[illegible]	300JL
5/2/12	KH	300KH
5/3/12	[illegible]	100TRG
5/3/12	[illegible]	100JP
5/14/12	TJCM	300TM
Classification ENV-7.00		
Project 12		
Control No. 6029874		
Folder I.D. 1198308		

IN REPLY REFER TO:
KO-300
ENV-7.00

MAY 3 2012

Ms. Irma Lagomarsino
National Marine Fisheries Service
1655 Herndon Road
Arcata, CA 95521

Subject: Request for Species and Critical Habitat Located Within the Action Area Related to Klamath Project Operations.

Dear Miss Lagomarsino:

The Bureau of Reclamation is currently in the process of preparing a Biological Assessment to evaluate the potential effects of and determine if Klamath Project (Project) operations may affect listed species and/or their designated or proposed critical habitat. Specifically, Reclamation proposes to divert, store, and convey Project water to meet authorized Project purposes and contractual obligations in compliance with applicable law.

Current analysis indicates the action area likely includes the area within the boundaries of the Klamath Project located in southern Oregon and northern California, and the Klamath River from Upper Klamath Lake to the mouth at Klamath, California (see enclosed map). The enclosed table illustrates the species that may be present in the action area and which may be affected by Project operations.

To appropriately evaluate and determine if the proposed action has the potential to affect threatened and/or endangered species, Reclamation is requesting a list of species and critical habitat which may be present in the action area as required under the Endangered Species Act (50 CFR § 402.12(c)). Please review and provide a current species and critical habitat list at your earliest convenience.

If you have any questions, please contact Jennie Land by phone at 541-880-2572, or via e-mail at jland@usbr.gov.

Sincerely,

JASON R. PHILLIPS

Jason Phillips
Area Manager

Enclosures - 2

cc: Jim Simondet
Steve Hillyer
Laurie Sada

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
1655 Heindon Road
Arcata, CA 95521-4573

MAY 10 2012

Mr. Jason Phillips
Bureau of Reclamation
6600 Washburn Way
Klamath Falls, Oregon 97603-9365

Dear Mr. Phillips:

Thank you for your May 3, 2012, letter regarding the presence of Federally listed species and designated Critical Habitat that may be affected by the continued operation of the Klamath Project. Available information indicates the following listed species and critical habitat may occur in the Project area in the Klamath River and its tributaries.

> Southern Oregon/Northern California Coast (SONCC) coho salmon (*Oncorhynchus kisutch*) Evolutionarily Significant Unit (ESU), listed as threatened under the Endangered Species Act (ESA) on June 28, 2005 (70 FR 37160).
>
> Southern Distinct Population Segment (DPS) of Pacific eulachon (*Thaleichthys pacificus*), listed as threatened under the ESA on March 13, 2009, (74 FR 10857).
>
> Southern DPS of North American green sturgeon (*Acipenser medirostris*), listed as threatened under the ESA on April 7, 2006 (71 FR 17757).
>
> Southern Resident DPS killer whale (*Orcinus orca*) listed as endangered under the ESA on November 18, 2005 (70 FR 69903).
>
> Critical Habitat for SONCC coho salmon, designated on May 5, 1999 (64 FR 24049)
>
> Critical Habitat for the Southern DPS of Pacific eulachon, designated on October 20, 2011 (76 FR 65324)

The Klamath River within the proposed Project area is also designated Essential Fish Habitat (EFH) pursuant to the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) for Chinook salmon (*O.tshawytscha*) and coho salmon under the Pacific Coast Salmon Management Plan. The website (http://swr.nmfs.noaa/efh.htm) provides more EFH information.

If you have any questions concerning these species, please contact Stephen Hillyer at (541) 885-2504, or via email at stephen.hillyer@noaa.gov.

Sincerely,

Irma Lagomarsino
Northern California Office Supervisor

cc: ARN 151422SWR2011AR00315
Laurie Sada, USFWS, 1636 California Avenue, Klamath Falls, Oregon 97601

Appendix 4A Proposed Action Development

Appendix 4A-1: Model Documentation

Appendix 4A-1

Contents

FIGURES

TABLES

A.4.1 Model Overview

The Klamath Basin Planning Model (KBPM) was used to simulate the operation of the Klamath River system over a range of hydrologic conditions. The model is a generalized reservoir-river basin simulation model that allows for specification and achievement of user-defined goals. Figure A.4.1.1 shows the overall Klamath River watershed and the Klamath and Lost Rivers. The KBPM extent covers from Upper Klamath Lake to Iron Gate Dam, just upstream of the Shasta River confluence.

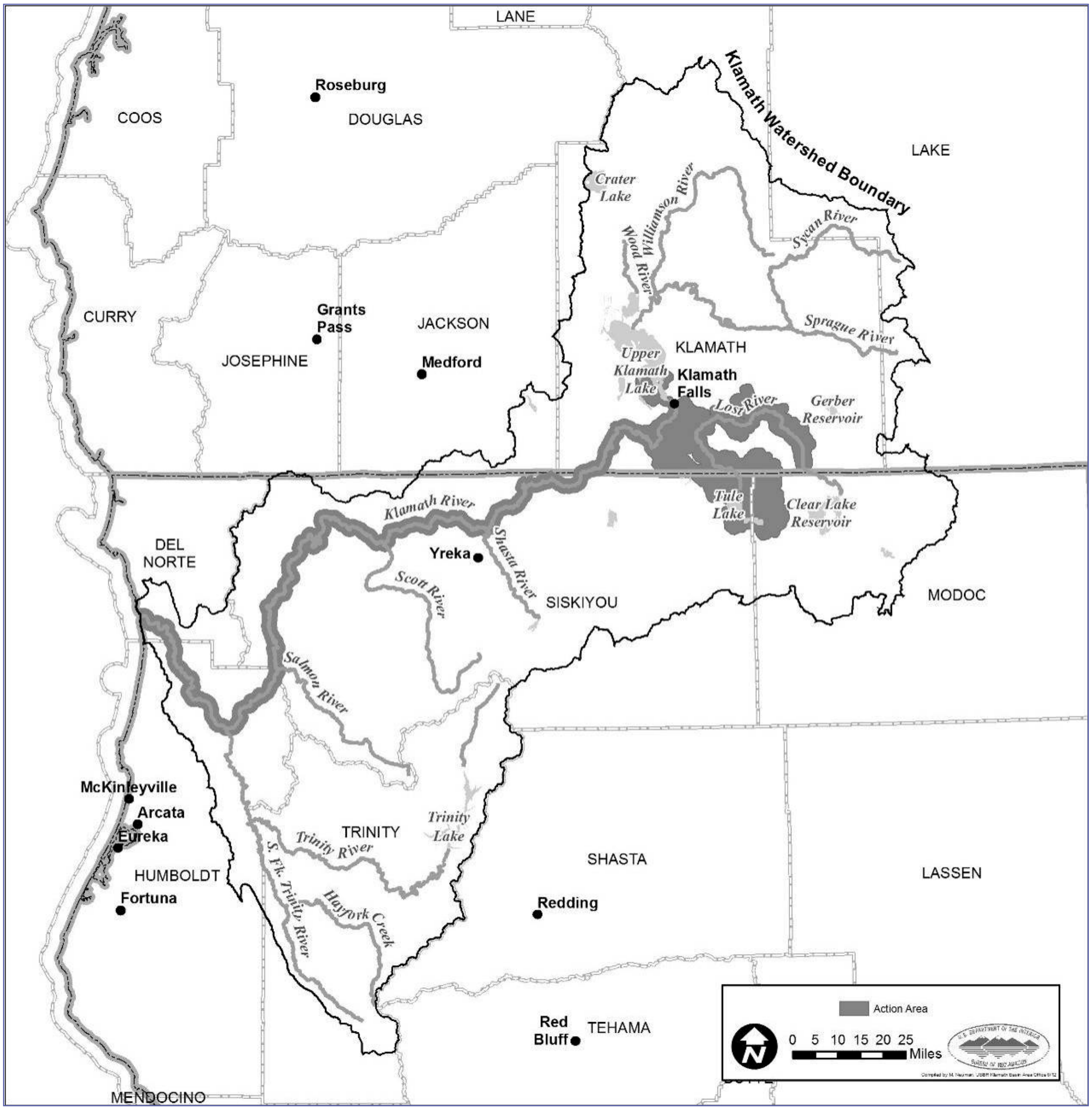


Figure A.4.1.1 Location of Upper Klamath Basin, Oregon and California, and Locations of Major Rivers.

Inputs to the KBPM were developed at a daily timestep and include water diversion requirements (demands), system gains and losses (accretions), Upper Klamath Lake (UKL) net inflows, inflow from the Lost River through the Lost River Diversion Channel (LRDC), and return flow ratios. The Klamath Basin daily inflow data set was developed by a working team of hydrologists and modelers from various organizations (Federal and non-Federal) using historical data from a variety of sources for the 30-year period including water years 1981 to 2011. The resulting hydrology represents the water supply available from the Klamath River system to the service area at the current level of development. This data development is discussed further in Section A.4.3.

The Klamath Basin Planning Model produces daily outputs for river flows, project diversions (including deliveries to the Lower Klamath National Wildlife Refuge (LKNWR)) and reservoir storage. The model output also serves as input data for other analysis tools.

It's important to note that the KBPM is a planning tool that assisted in the development of the Proposed Action and all of the processes built into the model cannot be implemented during actual operations. For example, monthly distribution patterns were developed to simulate the delivery of the Project irrigation deliveries for the KBPM modeling exercise. These distribution patterns were developed by analyzing historical irrigation demand patterns and taking the average percent distribution for each month. Real-time implementation of the Proposed Action will not result in these same irrigation delivery distribution patterns. The actual distribution of the Project Supply is heavily dependent upon current hydrologic and meteorologic conditions and will vary from year to year. This is just one example of how the processes built into a planning model cannot be implemented, and/or are not intended to be implemented, during actual operations.

A.4.2 WRIMS and WRESL Code

The KBPM is built on the Water Resources Integrated Modeling System (WRIMS) platform. WRIMS uses a mixed integer linear programming solver to route water through a user-defined network of flow arcs and nodes representing locations in the river system. Policies and priorities for water routing are implemented through user-defined weights applied to flow arcs and storage nodes in the network. System variables and the constraints on them are specified with a scripting language called the "water resources engineering simulation language" (wresl). Wresl code is developed in simple ascii text files. Time series input data and model results are stored in HEC-DSS files. Relational data (lookup tables) is stored in ascii text files.

A.4.3 Model Representation

A.4.3.1 Modeled Rivers, Lakes, Conveyance Facilities, and Model Schematic

The KBPM simulates water-supply related operations of the Klamath Irrigation Project within the Klamath River system. Because this model operates on a mass-balance basis, project operations which do not affect water supply such as pesticide use or intermittent maintenance operations were not modeled. Within this system, the components that are specifically modeled include Upper Klamath Lake (UKL), Lake Ewauna (the headwaters of the Klamath River), Klamath River down to Iron Gate Dam, and all associated Reclamation-owned facilities that are expected to be operable over the time period covered by this Biological Assessment. Facilities include the Link River Dam, A Canal, Lost River Diversion Channel (LRDC), North Canal, Ady Canal, Klamath Straits Drain and all associated pumping facilities.

The model does not include the Lost River system. The Lost River system east of Harpold Dam is operated as a closed system during the irrigation season when the releases from Clear Lake and Gerber Reservoir (and any natural flow) equal the water used prior to flows reaching Harpold Dam. Harpold Dam is a flash board dam where the flash boards are added and removed as needed. The boards are up when releases are being made from Clear Lake and Gerber reservoirs (typically during the spring and summer period) and are removed once the dams stop releases for the fall and winter time period. Downstream of Harpold Dam, the Lost River is diverted into the Lost River Diversion channel at Lost River Diversion Dam. This diversion either flows into Station 48 (when open) or continues flowing into the Klamath River. The KBPM accounts for flows from the Lost River to the Lost River Diversion channel through a historical daily input time-series (I91). This value is very low when Harpold Dam is operational because it is comprised only of Harpold Dam leakage, runoff and return flows between Harpold and Wilson Dams. When Harpold Dam is not operational, this value can be very high as it includes the entire flow of the Lost River.

Return flows from the A2 area (which receives water from North and Ady canals) and the Lower Klamath National Wildlife Refuge is also incorporated (Figure A.4.3.1). The direct effect of Project operations end at the Klamath Straits Drain above Keno Dam, Oregon, which is the last Reclamation Project feature, although the model itself simulates operations down to Iron Gate Dam with the daily accretion between Keno Dam and Iron Gate Dam based on historical data. The model schematic is shown in Figure A.4.3.2. For a more detailed description of each link and object referenced on the schematic, please see the definitions in Table A.4.3.4.1 – Key Model Variables.

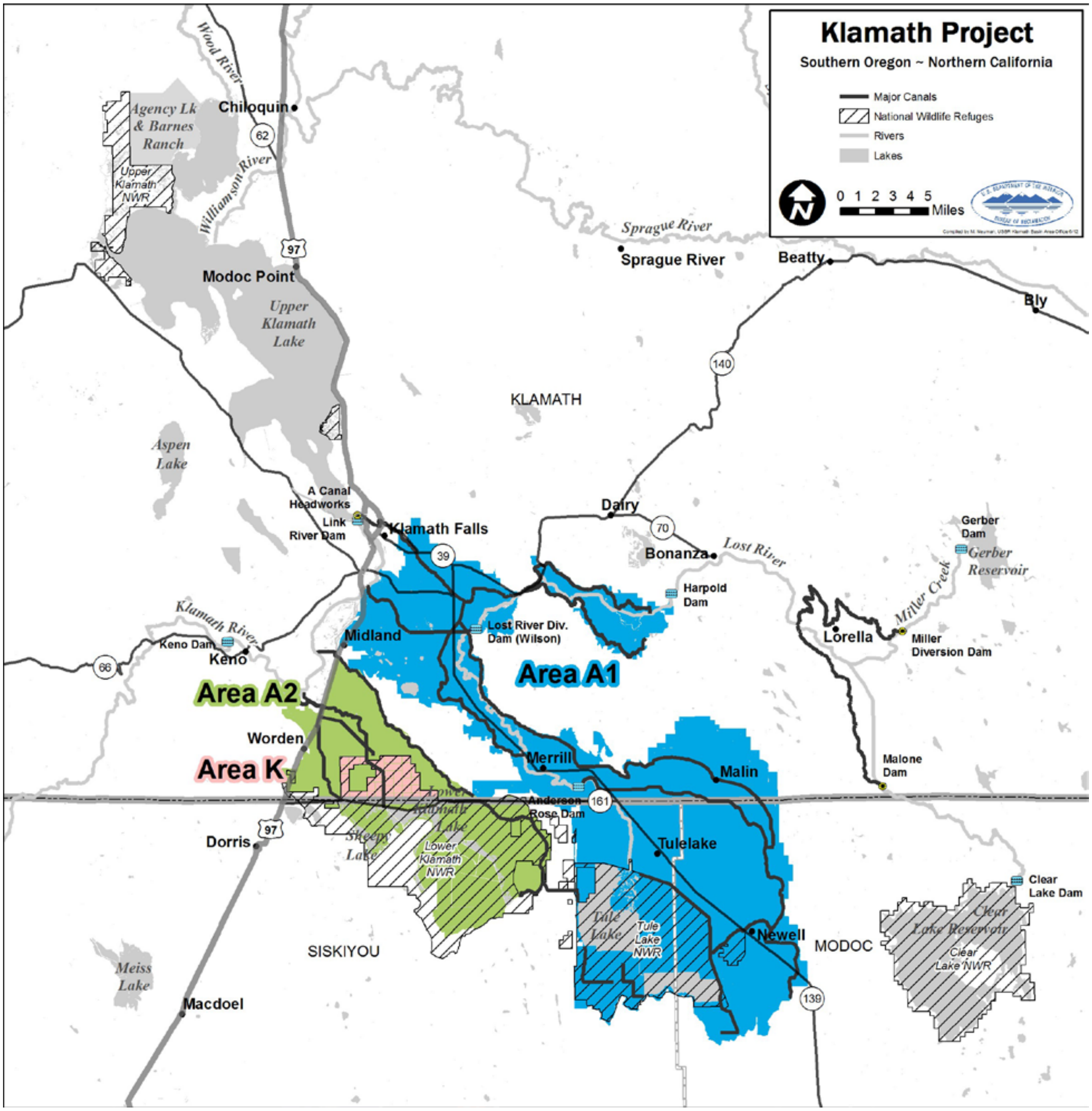


Figure A.4.3.1 Klamath Projects, Oregon and California

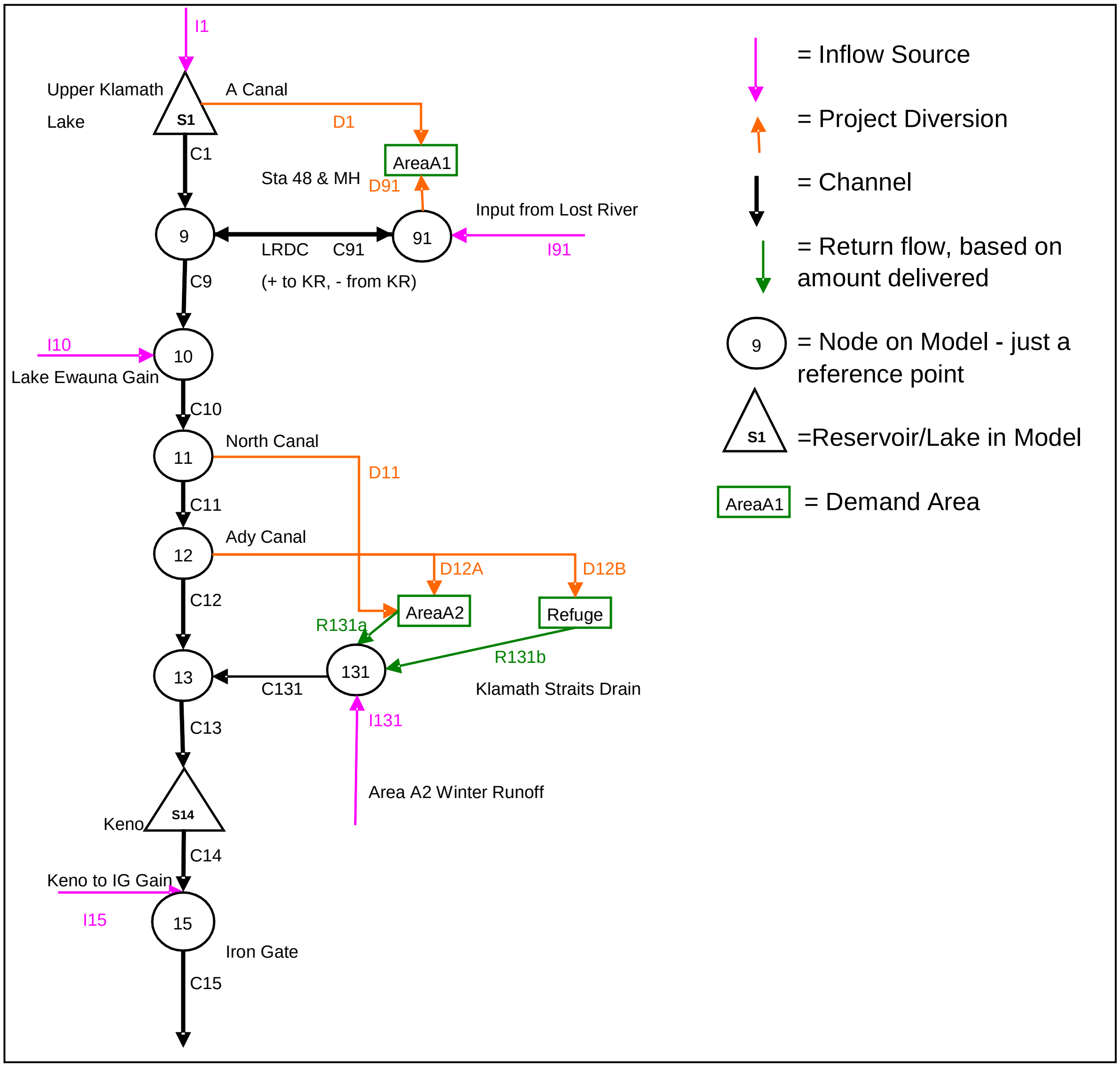


Figure A.4.3.2 Model Schematic

A.4.3.2 Period of Record

Previous operational consultations have used an older WRIMS model which operated on monthly and twice monthly (monthly except March through July which were bi-weekly). Past models also used a longer period of record with water years 1961-2006. The current KBPM uses a daily timestep, starting October 1, 1980 and running through September 30, 2011. The period between water years 1981 through 2011 includes the recorded wettest and driest inflow years along with a reasonable distribution of wet, average and dry years. With this range of data, the model can evaluate a particular operations strategy across the full available range of inflows.

The daily timestep 31-year input data set provides the following advantages over the 17-time step 47-year inputs.

- Essential daily data inputs are available electronically for water years 1981-2011. Daily data for 1961-1980 is not in a usable format and would require extensive reprocessing and review before it could be used for modeling.
- Updated forecasts from the Natural Resources Conservation Service (NRCS) for March, April, May and June are only available from 1981-2011. These forecasts were updated based on the new, current forecasting methods and therefore better reflect how the proposed operation (which is based heavily on forecasts) would affect overall water conditions.
- 1981-2011 still includes the widest range of hydrologic conditions (lowest (1992) and highest (1983) inflow years), and includes various multi-year hydrologic cycles:
    - Oscillating extreme years such as 2005/2006/2007 where UKL net inflows for April-September measured 360/758/358 thousand acre-feet (TAF), respectively.
    - Repetitive wetter years such as 1982/1983/1984 where UKL net inflows for April-September measured 721/895/839 TAF, respectively.
    - Repetitive drier years such as 2001/2002/2003 where UKL net inflows for April-September measured 242/341/373 TAF, respectively.

A.4.3.3 Hydrology Inputs

A.4.3.3.1 Definitions

Quality Assurance is process oriented: to make sure the correct things are done in the correct manner. Planned and systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled. In the context of data sets for the WRIMS model, quality assurance will relate to the configuration of the physical infrastructure of water diversions structures, gauging systems, and how data are collected.

Quality Control is product oriented: to make sure the results meet the expectations of the Project. It includes the techniques and activities used to fulfill requirements for quality. QC emphasizes testing of products to uncover defects. In the context of data sets for the WRIMS model, quality control will relate to proofing of the data and correcting/adjusting data so that a final reliable dataset is created.

A.4.3.3.2 Data Sets

1. Project Daily Data and Project Historic Use Data
2. Upper Klamath Lake net inflow
3. Lake Ewauna accretions
4. Keno Dam to Iron Gate accretions
5. Lost River Diversion Channel inflow from the Lost River
6. Area 2 winter runoff
7. Natural Resource Conservation Service forecasts
8. Crater Lake precipitation

A.4.3.3.3 Project Daily Data and Project Historic Use Data

Electronic data from sources listed below were combined into one file and compared to a 2010 version of Reclamation's MODSUM file. The electronic data were then compared with hard copies of Klamath Irrigation Project Daily Operations Reports. Comparison was completed on a day by day basis for A Canal, Lost River Diversion Channel (LRDC) total flow, Station 48, Miller Hill Pump, Miller Hill Spill, ungauged Klamath Irrigation District pumping plants, North Canal, Ady Canal, Ady Canal to Lower Klamath Lake Refuge, Klamath Straits Drain, F pump, FF pump, and ungauged Area 2 diversions.

Quality control of the project data began with the following electronic Excel files provided by Reclamation:
KHYDRODBA_1994-2010_Crop_Averages
KHYDRODBA_ADYCANAL
KHYDRODBA_ADYREFUGE
KHYDRODBA_KIDPUMPS
KHYDRODBA_KSCHAN
KHYDRODBA_LRDCHAN
KHYDRODBA_NORTHCAN
KHYDRODBA_PUMPF_FF
KHYDRODBA_TIDSTUFF
KHYDRODBA_UKLDATA
KHYDRODBA_WESTCAN
Klamath_Project_Drainage_Through_TID
Pacificorps_KLA_0506_Flows_REV

The quality controlled daily project dataset was finalized for October 1, 1974 through September 30, 2011 for Area 1, and January 1, 1980 through September 30, 2011 for Area 2. For Water Year 2011, data after December 25, 2010 are from electronic records and were not checked against hard copy Daily Operations Reports because the reports had not been prepared. Where differences existed between the hard copy and electronic data, hard copy Operations Reports were assumed to be correct and the electronic records were modified to match the Operations Reports. Short (1 to 3 days) data gaps were filled with synthesized data generated using linear interpolation. Longer data gaps were filled using other Reclamation or water district records.

Within the KBPM, the Historic Project Use table has been updated several times as new and revised data have been included. Updates include adding ungauged Area 1 data, ungauged Area 2 data, revisions to the Station 48 data, and minor corrections to calculation of historic project use. The most recent update was in August 2012 to incorporate revised water bank values between 2001 and 2010. The WRIMS model uses project data as yearly sums for the period of record in a lookup table. However, the raw daily project data, or subsets, are used in calculating UKL net inflow, Lake Ewauna accretions, and LRDC inflow from the Lost River.

Project daily data are contained in the spreadsheet: **Daily_Project_diversions_1975-2011(A1)_1980-2011(A2)_DRAFT_June_25_2012.xlsx**.

Project historic use data are contained in the spreadsheet: **HisAgUseCalcs_rev_June_25_2012.xlsx**. In WRIMS, historic use data are contained in the file: **histprjuse.table**.

A.4.3.3.4 Upper Klamath Lake Net Inflow

The Upper Klamath Lake (UKL) daily net inflow dataset is calculated from quality-controlled data for (1) A Canal diversions (Reclamation), (2) average daily flows for the Link River at Link River Dam (USGS), (3) Westside Power Canal (often referred to as the Keno Canal) flows (PacifiCorp), (4) Agency Lake Ranch and Caledonia operations (Reclamation), and (5) active storage data for UKL (Reclamation). Additional minor revisions will be required because in July and August 2012 Reclamation recalculated Agency Lake Ranch data, based on revised pump efficiency curves.

Storage volume in UKL is dependent on the elevation of the lake surface and the capacity of the lake, and the capacity has varied over time. The UKL net inflow dataset elevation-capacity relationships are as follows:

- October 1, 1980 through July 7, 2006: UKL without Caledonia, Tulana, or Goose Bay
- July 7, 2006 through December 31, 2006: UKL with Caledonia
- January 1, 2007 through October 30, 2007: UKL without Caledonia, Tulana, or Goose Bay
- October 31, 2007 through November 17, 2008: UKL with Tulana
- November 18, 2008 through September 30, 2011: UKL with Tulana and Goose Bay

The UKL daily net inflow is calculated using the following equation:

Net Inflow = {(UKL storage volume today – UKL storage volume yesterday) + (Link River + Westside Canal) + (A Canal) + (Volume pumped to Agency Lake Ranch [positive]

Or

{(Volume pumped from Agency Lake Ranch [negative]) – (Volume from Caledonia Marsh)}.

The KBPM uses both raw daily data and a 3-day moving average of the daily data for UKL inflow. The raw daily data input variable is I1_raw and is used in a calculation of cumulative inflow into UKL. The moving average of the previous 3 days of inflow input variable is I1 and defines the Available Inflow above Link River Dam (AIL) term used in the Fall-Winter River Operations, as well as providing the inflow element of the mass balance equation for UKL.

Upper Klamath Lake net inflow data are contained in the spreadsheet: **UKL_DailyNetInflow_FINAL_21May2012.xlsx**. In KBPM, the time series' I1_raw and I1, for UKL daily net inflow and 3-day moving average data are contained in the file: **DailyPA_SV.dss**. Upper Klamath Lake head-area-capacity data for the current configuration of UKL are contained in the spreadsheet: **ReservoirInfoLookupTables_FINAL_updated-02May2012.xlsx**. In KBPM, this data is contained in the files: **res_info.table** and **res_info2.table**.

A.4.3.3.5 Lake Ewauna Accretions

The Lake Ewauna daily accretion dataset is calculated from quality controlled data for (1) LRDC spill to the Klamath River, (2) LRDC delivery to Area 1 from the Klamath River, (3) pumps F and FF, (4) North Canal, (5) Ady Canal, (6) Unguaged Area 2 diversions, (7) PacifiCorp data for the Westside Power Canal, and (8) USGS average daily flow data for Link River at Link River Dam and Klamath River at Keno Dam.

The Lake Ewauna accretions are calculated using the following equations:

Accretions = (Measured Keno Flow) – (Computed Keno Flow), and

Computed Keno Flow = [(Link River + Westside Canal) + (LRDC spill to the Klamath River) + (Pumps F and FF) – (LRDC delivery to Area 1 from the Klamath River) – (North Canal) – (Ady Canal) – Ungauged Area 2 diversions)]
The WRIMS model uses a 3-day moving average of the daily Lake Ewauna accretion data. The input variable is I10.

Lake Ewauna accretions data are contained in the spreadsheet: **Lake Ewauna accretions FINAL May 21 2012.xlsx**. In KBPM, Lake Ewauna accretion data are contained in the file: **DailyPA_SV.dss**.

A.4.3.3.6 Keno Dam to Iron Gate Dam Accretions

The Keno Dam to Iron Gate Dam daily accretion dataset is calculated from USGS average daily flow gage data for the Klamath River at Keno Dam and Iron Gate Dam, and the Scott and Shasta Rivers. The accretion value was proportioned on Scott and Shasta River flows to impose a reasonably normative yearly hydrograph on the Klamath River reach between Keno and Iron Gate dams, which is highly regulated and includes several reservoirs.
Average daily flow (cubic feet per second [cfs]) data for the Scott and Shasta rivers were converted to average daily volume (thousands of acre-feet [TAF]) using the following equation:
Thousands of acre-feet = (flow in cfs) * [(86,400 seconds per day) / (43,560 cubic feet per acre-foot) / (1,000)].

The daily volume data for each river were then divided by the total monthly volume for that respective river to develop a proportional volume for each day of the month for each river. The daily proportional volume for each river was then multiplied by the monthly volume of accretions between Keno Dam and Iron Gate Dam to develop two sets of accretions between Keno and Iron Gate: one proportioned to the Scott River and one proportioned to the Shasta River. The two sets of proportioned accretion data were then averaged to create one dataset of daily accretions between Keno Dam and Iron Gate Dam.
The KBPM model uses a 5-day moving average of the daily proportioned Keno Dam to Iron Gate Dam accretion data. The input variable is I15.

Keno Dam to Iron Gate Dam accretions data are contained in the spreadsheet: KenoIGDAccretionsDaily_30Sep2011_FINAL.xlsx. In KBPM, Keno Dam to Iron Gate Dam accretion data are contained in the file: **DailyPA_SV.dss**.

A.4.3.3.7 Lost River Diversion Channel Inflow From Lost River

Lost River return flows are diverted into the Lost River Diversion Channel at the Lost River Diversion Dam. Data for these return flows are included in the QA/QC'ed **Daily_Project_diversions_1975-2011(A1)_1980-2011(A2)_DRAFT_June_25_2012.xls** dataset..

A.4.3.3.8 Area 2 Winter Runoff

The Area A2 Winter Runoff data input was added as a water balancing term to ensure all water remained within the system. The name of this data value originated in previous models and was retained for continuity; however this value represents more than only winter runoff. This data value is simply the difference of actual, historical pumped return flow at pumping plants F and

FF and known values that discharged into the Straits Drain. Pumping plants F and FF pump water from the Straits Drain into the Klamath River and receive direct discharge from the LKNWR as well as return flows from project area A2. In the winter and spring, precipitation events may create runoff that also drains into the Straits Drain from any point along the drain. In addition, gage errors, changes in pumping efficiency, changes in canal dimensions and increased or decreased efficiency in area A2 water use could all contribute to this balancing term. This formula is as follows:

A2 Winter Runoff = F/FF – LKNWR@Stateline - (%Return*A2 Deliveries)

The % return value is discussed later in the documentation in Section 4.4.5, but is equal to 30% or 40% depending on the month.

This value was updated from previous models in late 2011 and was not updated with the corrected daily historical deliveries that were developed during 2012, as explained in other sections. Therefore, this value was calculated on a monthly basis as the monthly volume pumped at pumping plants F and FF less the expected return flow from A2 less the LKNWR monthly return flows at Stateline Road. These values were divided by the number of days in each month in order to incorporate into the daily time step WRIMS model.

A.4.3.3.9 Natural Resources Conservation Service Forecasts

The Natural Resources Conservation Service (NRCS) provided reconstructed UKL net inflow forecasts for water years 1981 through 2011 using the most recent version of the UKL calculated net inflow data (see above). The most recent reconstructed forecasts were completed by NRCS in April 2012.

NRCS forecast reconstructions are contained in the spreadsheet: **NRCS_Klamath_forecast_reconstructions_FINAL_11Apr2012.xlsx**. In KBPM, NRCS forecast data are contained in the file: **forecasts50pct.table**.

A.4.3.4 Key Model Variables

In many cases, the actual variables used in the model code have names which are not clearly descriptive of their definition. This is a function of multiple model developers, changing intentions and strategies and general model adaptation. In order to connect the actual model code to the operations described below, please use the table of key model variables listed in Table A.4.3.4.1. This table provides an overview definition of each key variable with a common name (as referenced in the operations sections below) and location within the model files. Due to size, this table is located in Section A found at the end of this document.

A.4.4 Simulated Operations

A.4.4.1 Fall-Winter Operations

The Fall-Winter Klamath Project Rules of Operation are intended to divide the available Fall-Winter water supply between the following competing goals:

1. Fill UKL for the upcoming irrigation season and critical fish habitat needs.
2. Release sufficient flow from Link Dam to meet downstream fish needs.

3. Meet Fall-Winter project demands:
   a. Klamath Drainage District (Area A2 – serviced by North Canal and Ady Canal)
   b. Lease Lands in Area K (within area A2 – serviced by Ady Canal, Figure A.4.3.1)
   c. Lower Klamath National Wildlife Refuge (serviced by Ady Canal)

Additionally, sufficient flood pool capacity must be maintained in UKL to protect the surrounding lake levees.

In October and November, there is overlap between the Spring-Summer and Fall-Winter operation because Area 1 and the LKNWR will likely divert a portion of the Spring-Summer Agriculture and Refuge supplies during these months. Spring-Summer and Fall-Winter diversion accounts must be kept separate during the overlap period.

During the Fall-Winter season, the Klamath Drainage District (KDD) is provided a reserve supply of 19.234 TAF via a state water right. The remaining water supply that becomes available during the Fall-Winter season is divided between downstream flow, KDD, LKNWR, Area K, and UKL. The division is determined using the Williamson River flow forecast and the current cumulative Williamson River flow as compared to historical data, but is also affected by how fast UKL is filling and the current flows along the Klamath River below Iron Gate Dam. Flows below Iron Gate Dam are heavily affected by the accretions downstream of Keno Reservoir. In wetter hydrologic patterns, or during periods immediately following lower-basin storms, the downstream accretions can account for a substantial portion of the flows downstream of Iron Gate Dam.

Following are instructions for implementing Fall-Winter Klamath Project operations.
All Fall/Winter releases from UKL for Iron Gate flows are computed as a multiplier times the previous day's Williamson River inflow, further adjusted by additional factors. The exact determination varies by month and hydrologic condition, as detailed in this section. Key model variables referenced throughout this document can be defined in Table A.4.3.4.1 found in Section A at the end of this document.

1. Lookup **Link_min**, which is the minimum flow release from Link River Dam from Oct-Feb. Link River minima are only for modeling purposes and lower Link River flows may be observed in real-time operations.

Table A.4.4.1.1 Link River Dam Minimum Flow Release

Month	**Link_min (cfs)**
October	400
November	400
December	300
January	300
February	300

2. Lookup **IGmin**, which is the minimum flow release from Iron Gate Dam (minima for other months not shown here):

Table A.4.4.1.2 Iron Gate Minimum Flow Release

Month	IG_MIF (cfs)
October	1000
November	1000
December	950
January	950
February	950

3. Consider the fill rate needed to achieve a UKL level of 4142.8 ft by March 1, and compute an adjustment factor based on any difference between recent operations and what is required. This adjustment factor helps to back off on release requirements when filling has been slower than needed, and to allow additional release when filling is ahead of schedule.

   a. Calculate **Needed_fill_rate**, which is the average daily fill rate from yesterday's UKL level to attain 4142.8 ft on March 1.

      Needed fill rate = (4142.8 ft – UKLelev(-1)) / (152-days_since_Oct1)

   b. Calculate **Recent_fill_rate**, which is the average daily fill rate of prior week, based on difference between UKL level from yesterday and from 7 days ago.

      Recent fill rate = (yesterday's UKL elevation– UKL elevation from 7 days ago)/7

   c. Calculate **Fill_rate_diff**, Positive values indicate that recent fill rates exceed the average rate needed to reach 4142.8 ft on March 1. Negative values indicate that recent fill rates fail to achieve the average rate needed to reach 4142.8 ft on March 1.

      Fill rate diff = Recent_fill_rate - Needed_fill_rate

   d. Look up **Fill_rate_adjust**, adjusts the proportion of the Williamson River flow intended for release at Link River Dam from November 16 through February to account for the fill trajectory in UKL. Dry means UKL_cum_inf_index < 0.3, see Table A.4.4.1.6. Use of this variable begins on November 16, because Oct-Nov 15 is a transitional period in which lake level stops declining and then changes to a re-fill trajectory. In addition, Oct-Nov 15 is biologically sensitive (e.g. spawning), and subject to highly variable accretions between Link and Iron Gate dams. Therefore, no adjustments are made to enhance UKL re-fill during this period.

Table A.4.4.1.3 Fill Rate Adjustment Factor

Fill_rate_diff (ft/day)	Fill_rate_adjust_wet	Fill_rate_adjust_dry
-999	0.6	0.2
-0.02	0.6	0.2
0	1	1
0.03	1.4	1
999	1.4	1

4. Lookup **Will_prop**, which is the proportion of yesterday's Williamson River flow initially targeted for release from Link Dam. In lookup table, where $WillQ_{-1}$ is yesterday's Williamson River flow:

Table A.4.4.1.4 Williamson River Release Target Proportion

October		November		December		January		February	
WillQ-1 (cfs)	Will_prop	WillQ-1 (cfs)	Will_prop	WillQ-1 (cfs)	Will_prop	WillQ-1 (cfs)	Will_prop	WillQ-1 (cfs)	Will_prop
0	1	0	1	0	0.85	0	0.85	0	0.85
500	1	500	1	450	0.85	450	0.85	450	0.85
650	1.25	1173	1.25	800	0.9	800	0.9	800	0.9
1000	2	3192	2	1000	1.5	1000	1.5	1000	1.5
4000	2.3	4000	2.3	2000	1.9	2000	1.9	2000	1.9
9999	2.3	9999	2.3	4000	2.3	4000	2.3	4000	2.3
				9999	2.3	9999	2.3	9999	2.3

5. Calculate **Net_accrete**, which is the volume of yesterday's accretions and depletions between Link River and Iron Gate dams.

$$\text{Net\_accrete} = \text{C91\_F}_{-1} + \text{C131}_{-1} - \text{D11\_ss\_LRDC}_{-1} - \text{D12A\_ss\_LRDC}_{-1} + \text{I10}_{-1} + \text{I15}_{-1}$$

where:

C91_F_{-1} = Lost River Diversion Channel flow to the Klamath River

C131_{-1} = flow into the Klamath River from pumps F and FF

D11_ss_LRDC_{-1} = flow from the Lost River Diversion Channel routed to North Canal

D12A_ss_LRDC_{-1} = flow from the Lost River Diversion Channel routed to Ady Canal

I10_{-1} = Lake Ewauna accretions: net of ungauged inflows and outflows, and gauge error

I15_{-1} = Accretions between Keno and Iron Gate dams

-1 = the previous day

6. Determine **Accrete_adjust**, which adjusts Link River Dam releases based on net accretion conditions between Link River and Iron Gate dams. Low net accretions cause a need for higher Link releases in order to produce acceptable flows at Iron Gate Dam, something that can be a significant management issue during Oct-Dec. The Accrete_adjust variable adjusts Link releases in Oct-Nov 15 in all years, but during Nov 16-Dec it is only applied when conditions are relatively dry ($UKL\_cum\_inf\_ind_{-1} < 0.3$). Values for Accrete_adjust are looked up according to values of Net_accrete in Table A.4.4.1.5:

Table A.4.4.1.5 Net Accretion Adjustment Factor

October		**November**		**December**		**January**		**February**	
Net_accrete (cfs)	accrete _adjust	Net_accrete (cfs)	accrete _adjust	Net_accrete (cfs)	accrete _adjust	Net_accrete (cfs)	accrete _adjust	Net_accrete (cfs)	accrete _adjust
-58	1.2	43	1.2	60	1.2	140	1	303	1
198	1.2	163	1.2	171	1.2	258	1	354	1
397	1	377	1	342	1	410	1	525	1
510	1	494	1	415	0	473	0	589	0
585	0.4	566	0.4	9999	0	9999	0	9999	0
9999	0.4	9999	0.4						

7. Compute OctNov_Augment, based on the portion of the Environmental Water Account (EWA) which was carried over from the previous Spring/Summer operations season. This volume of water is divided evenly over the 61 days in October and November, and will be added to the Link River release target in these months.

8. Calculate **Link_release_FW**, which is the Link River Dam release target as:

Table A.4.4.1.6 Calculation of Fall/Winter Link River Dam Release Target

Condition	Equation
Oct-Nov 15	(Will_prop * Will_Riv_inf $_{-1}$ * Accrete_adjust) + OctNov_augment
Nov 16-30, UKL_cum_inf_ind < 0.3 (dry)	(Will_prop* · Will_Riv_inf$_{-1}$* Fill_rate_adjust * Accrete_adjust) + OctNov_augment
Nov 16-30, UKL_cum_inf_ind > 0.3 (wet)	(Will_prop * Will_Riv_inf$_{-1}$* Fill_rate_adjust) + OctNov_augment
Dec – Feb, UKL_cum_inf_ind < 0.3 (dry)	Will_prop * Will_Riv_inf$_{-1}$ * Fill_rate_adjust * Accrete_adjust
Dec – Feb, UKL_cum_inf_ind >0.3 (wet)	Will_prop * Will_Riv_inf$_{-1}$* Fill_rate_adjust

9. Consider Link River minimum flow and Iron Gate minimum flow (both minimum flow criteria are used for modeling purposes – real time operations may be different) in the final calculation of **Link_WF_target**, which is the release from Link River Dam in the C1_MIF arc (can be over-ridden by ramp rate restriction) as:

   max(Link_min, release necessary to meet IGmin, Link_release_FW)

10. Calculate **Fill_vol**, the volume of UKL storage which still needs to be filled to attain the end-of-Feb target level of 4142.8 ft.

11. Calculate **Fill_flow**, the average daily inflow required to fill UKL to the end-of-Feb target of 4142.8 ft. In Jan or Feb, under wet forecast conditions (the NRCS 50% exceedence forecast for Mar-Sep net inflow to UKL, plus yesterday's UKL volume, minus a generic end-of-Sep UKL target of 4139 ft, exceeds 900 TAF) Fill_flow is set to zero. This condition acts as a check to determine whether it is likely that winter diversions would restrict the spring-summer Project supply. Otherwise,

   Fill_flow = Fill_vol/(151-days since October 1).

12. Calculate **FWavail**, the amount of water available for diversion by the Project and Refuge during Oct-Feb under fall-winter operations (note that under certain conditions the Refuge can get water by other means during Oct-Nov). When conditions are wet (UKL_cum_inf_ind$_{-1}$ > 0.8), FWavail should not constrain deliveries. Under more typical conditions from Oct-Feb, it is the UKL inflow that is not required to fill the lake or to release for river flows,

   FWavail = previous day UKL inflow – Link_WF_target – Fill_flow.

A.4.4.2 Spring-Summer Operations

The Klamath Project irrigation season runs from March 1st through September 30th, however irrigation often continues into October and November depending on the year type, crops planted and the hydrologic conditions at the end of each water year. The previous section described the Fall/Winter operations which are the first half of each water year. This section describes the second half of each water year, which covers the irrigation season. The irrigation season operations are controlled by defining the available project supply, which is computed from storage in Upper Klamath Lake, forecasted March-September inflow, and target carryover storage. Based on this supply, a portion is made available to the River and Project supply is computed based on multiple parameters. Any UKL inflow that is not delivered or released for flow will remain in UKL as storage. All water which leaves UKL through either Link River Dam or the A Canal is accounted for against one of these two identified volumes; this includes flood control releases. The Lower Klamath National Wildlife Refuge can receive a portion of the project supply or other delivery from UKL. Details for these operations are included in the sections below.

<u>Project Water Supply and Environmental Water Account for Klamath River Flows</u>

Both volumes are calculated on March 1st and April 1st with updates on May 1st and June 1st. The March and April processes divide up the UKL supply to help the irrigators and River managers plan out the spring and summer seasons. The May and June processes manage the change in supply by adjusting the volumes. The steps for determining the Project water supply and the Environmental Water Account (EWA) are below. Key model variables referenced throughout this section can be found in Table A.4.3.4.1 at the end of this Appendix 4A-1.

1. Calculate **UKLsupply** - The UKL supply is updated on the 1st of each month for March through June using the most current forecasted net inflow, the end of February storage and the end of September target. This formula is as follows (all values in TAF):

   UKLsupply = [End of February UKL Storage] + [50% exceedance forecast UKL inflow for March through September] – [End of September UKL Storage Target]

   a. The end of February UKL storage is simply the storage in UKL as determined on the last day of February. This is determined using the UKL weighted mean average elevation as determined by the United States Geological Survey (USGS) for that date along with the elevation-storage table included as Table A.4.4.2.1 found at the end of this Appendix.
   b. The forecasted UKL inflow for March through September changes each month from March through June. The formulas used for this variable (called **Mar50vol** in the model code) are as follows:
      i. March = [March 1st 50% exceedance probability forecast for UKL net inflows for March through September]
      ii. April = [April 1st 50% exceedance probability forecast for UKL net inflows for April through September] + [Actual Inflows that Occurred in March]
      iii. May = [May 1st 50% exceedance probability forecast for UKL net inflows for May through September] + [Actual Inflows that Occurred in March] + [Actual Inflows that Occurred in April]

iv. June = [June 1st 50% exceedance probability forecast for UKL net inflows for June through September] + [Actual Inflows that Occurred in March] + [Actual Inflows that Occurred in April] + [Actual Inflows that Occurred in May]

c. The **End of September UKL Storage Target** is determined each month, March through June, based on **Mar50vol** using Table A.4.4.2.2 below.

Table A.4.4.2.2 End of September UKL Storage Target

Mar50vol (TAF)	End of September Storage Target (ft)
210	4138.1
310	4138.1
620	4138.2
830	4138.35
1030	4138.54
1240	4138.75

2. Calculate **EWA river** as a percentage of UKLsupply. Look up the EWA_river percentage **EWA_sup_pct** based on UKLsupply in the table below, and

EWA_river = max(320, UKL_Supply * **EWA_sup_pct**)

Table A.4.4.2.3 EWA Percentages

UKLsupply (TAF)	EWA_sup_pct
500	0.53
600	0.53
900	0.57
1100	0.63
1300	0.7
1500	0.78
9999	0.78

3. Calculate the **Project Supply,**

a. The maximum Project Supply (prjSupply) is 390 TAF. If UKLsupply – EWA_River is greater than 390 TAF, the Project Supply equals 390 TAF. During model development, it was found that when the UKLsupply exceeded 1300 TAF, the [UKL supply minus EWA_River] equation resulted in a Project Supply less than 390 TAF. This situation typically occurred in wetter than average years when the Project historical demand from

UKL was less than 390 TAF. In these cases the model set the Project Supply equal the known historical demand to the Project. In the future, there will not be a known Project historical demand. Therefore, when the UKL supply is greater than or equal to 1300 TAF, the Project supply will be established at 390 TAF.

b. In March and April, Project Supply = UKLsupply – EWA_river.
c. In May and June, if UKLsupply has increased relative to the April determination due to improving inflow forecast, the project supply can be adjusted upwards if UKLsupply-EWA_river is larger than the previous project supply.
d. In June, if UKLsupply had decreased relative to the May determination, the project supply can be reduced, but to no lower than the April value.
e. The final determination for Project Supply is made in June, and is then fixed through the end of September.

A.4.4.3 Project Supply Use in Model

The historical demand (shown in the Table A.4.4.3.1 below) is loaded into the model and is used in conjunction with the assigned project supply to condition deliveries. This does not mean that the project water supply is limited by the historical demand, but rather the actual deliveries are limited by the historical demand.

Table A.4.4.3.1 Historical Project Demand from 1980 - 2011

Year	Historical Project Demand (TAF)
1981	408.2
1982	354.9
1983	358.4
1984	386.0
1985	423.2
1986	424.4
1987	444.8
1988	452.9
1989	407.4
1990	442.7
1991	440.1
1992	391.9
1993	365.5
1994	426.6
1995	356.5
1996	399.4
1997	423.9
1998	362.3
1999	447.8
2000	446.0
2001	422.3
2002	477.1
2003	404.2
2004	460.5
2005	424.8
2006	410.1
2007	452.7
2008	401.4
2009	389.7
2010	380.7
2011	367.4

The model takes the minimum of the project supply and the historical demand and divides it into the following components:

1. A Canal Supply – This is approximately 61% of the Project supply and is used April through October
2. Station 48 and Miller Hill Supply – This is approximately 22% of the Project supply and is used April through November

3. North Canal Supply – This is approximately 6% of the Project supply and is used March through September
4. Ady Canal Supply (Ag only) – This is approximately 11% of the Project supply and is used March through September

The fraction of the Project supply that is used each month is determined based on a distribution type that is chosen by the March 1st forecast, however this is only a mechanism of using the supply in a manner representative of the hydrologic conditions. Actual demands can vary greatly from month to month and even day to day.
The distribution type is determined using the following table along with the March 1st 50% exceedance probability forecast. The distribution type does not change after March 1st.

Table A.4.4.3.2 Distribution Type

March 1st Forecast (TAF)	**Distribution Type**
≤420	1
421-510	2
511-690	3
691-890	4
≥891	5

The monthly distribution patterns by month are shown below in Tables A.4.4.3.3 through A.4.4.3.6. These patterns were developed by analyzing historical demand patterns in each distribution type and taking the average percent distribution for each month. In the absence of a dynamically integrated project area consumptive use model, these monthly distributions serve as the best available methodology for apportioning the project supply through the irrigation season. Daily demands are calculated by dividing the monthly demand by the number of days in each month.

Table A.4.4.3.3 Distribution Patterns for A Canal Portion of the Supply

Distribution Patterns for A Canal Portion of the Supply					
Month	Distribution Type 1	Distribution Type 2	Distribution Type 3	Distribution Type 4	Distribution Type 5
April	9.80%	6.30%	6.50%	5.70%	3.00%
May	17.70%	13.00%	15.40%	15.80%	15.50%
June	20.10%	15.90%	18.10%	17.80%	20.50%
July	20.10%	20.30%	21.30%	22.30%	21.90%
August	18.90%	26.20%	20.10%	20.30%	19.80%
September	11.20%	14.00%	14.40%	13.70%	14.90%
October	2.20%	4.30%	4.20%	4.40%	4.40%

Table A.4.4.3.4 Distribution Patterns for Station 48 and Miller Hill Portion of the Supply

Distribution Patterns for Station 48 and Miller Hill Portion of the Supply					
Month	Distribution Type 1	Distribution Type 2	Distribution Type 3	Distribution Type 4	Distribution Type 5
March	3.10%	3.20%	1.20%	1.40%	0.20%
April	17.80%	7.60%	7.00%	5.60%	3.20%
May	11.00%	10.00%	10.50%	13.40%	15.00%
June	21.70%	21.60%	26.70%	23.90%	28.40%
July	20.60%	25.40%	28.20%	30.50%	28.70%
August	17.90%	22.00%	19.70%	19.70%	17.60%
September	6.20%	6.00%	4.20%	4.50%	5.90%
October	1.70%	2.60%	1.50%	0.90%	0.50%
November	0.00%	1.60%	1.00%	0.10%	0.50%

Table A.4.4.3.5 Distribution Patterns for North Canal Portion of the Supply

Distribution Patterns for North Canal Portion of the Supply					
Month	Distribution Type 1	Distribution Type 2	Distribution Type 3	Distribution Type 4	Distribution Type 5
March	9.90%	7.10%	6.40%	4.90%	3.00%
April	10.90%	9.10%	11.30%	12.40%	10.40%
May	20.90%	15.40%	20.30%	17.70%	24.90%
June	21.70%	23.70%	21.10%	22.40%	17.70%
July	15.50%	18.70%	15.30%	14.90%	15.90%
August	8.10%	11.50%	10.90%	13.60%	12.60%
September	13.00%	14.50%	14.70%	14.10%	15.50%

Table A.4.4.3.6 Distribution Patterns for Ady Canal (Ag Only) Portion of the Supply

Distribution Patterns for Ady Canal (Ag Only) Portion of the Supply					
Month	Distribution Type 1	Distribution Type 2	Distribution Type 3	Distribution Type 4	Distribution Type 5
March	16.20%	8.90%	11.50%	9.90%	4.60%
April	12.10%	8.20%	9.10%	6.60%	4.70%
May	13.30%	8.70%	11.90%	10.40%	10.40%
June	14.70%	14.60%	17.50%	19.50%	23.10%
July	16.10%	19.20%	18.20%	21.00%	18.30%
August	14.80%	21.60%	17.80%	16.90%	23.80%
September	12.80%	18.80%	14.00%	15.70%	15.10%

In some cases, the project may not use all of its supply due to use of water coming in from the Lost River through the Lost River Diversion Channel. In cases where this Lost River water was available, but the combination of available Lost River water and delivered Project supply were still less than the historical demand, any remaining supply is accounted for by modeling a supplemental October diversion through the A canal. This is a modeling device which ensures that the model does not cause simulated shortages to the project when the supply would not otherwise be fully used.

A.4.4.4 Project Return Flows

Project return flow results from delivered water which could not be fully consumed by the project land it was applied to. These return flows are considered separately for the three different irrigation areas of A1, A2 and the LKNWR (see Figure A.4.3.1).

Area A1 returns flow to the Lost River downstream of Harpold Dam. This return flow is accounted for through the time-series input of the Lost River to the Lost River Diversion Channel, or I91 in the model. It is understood that the return flow portion of the I91 input is dynamic, however more extensive analysis is required to determine how much of the Lost River to LRDC water was from return flows versus local runoff and leakage from Harpold Dam. This may be considered in future model updates.

Area A2 returns flow from the project through the Klamath Straits Drain, represented as C131 in the model. The Klamath Straits Drain carries return flows from the project and the Refuge along with local runoff from the surrounding area. The return flows which are considered to originate from the A2 project lands are calculated by the following formulas:

1. October through May, A2 Return flows = 0.4*[A2 Project Deliveries]
2. June through September, A2 Return flows = 0.3*[A2 Project Deliveries]

These values were determined in previous Klamath models and were assumed to be accurate for this model. The Refuge return flows are further discussed in the Refuge section below.
A2 and Refuge return flows are treated as accretions within the model to supplement the Klamath River flows.

A.4.4.5 EWA Use in Model

The EWA is accounted for through both intentional releases for the River through Link River Dam and releases for flood protection. The flood control releases are further described in Sections A.4.4.6 and A.4.4.8. Regardless of the intent of the release, all Link River releases that are not diverted to the Project (including the Refuge) are counted against the EWA. The distribution of the EWA is based on the patterns of Williamson River, below Chiloquin, gauged flows. The model calculates the distribution of EWA using the following steps:

1. Look up NRCS 50% exceedence forecasts for Williamson River flows.

2. Calculate **Will50vol**, which combines forecasted and observed Williamson River flows to track the expected Mar-Sep flow volume.

    i. March = [March 1st 50% exceedance probability forecast for Williamson River flows for March through September]

    ii. April = [April 1st 50% exceedance probability forecast for Williamson River flows for April through September] + [Actual flows that Occurred in March]

iii. May = [May 1st 50% exceedance probability forecast for Williamson River flows for May through September] + [Actual flows that Occurred in March] + [Actual Inflows that Occurred in April]

iv. June = [June 1st 50% exceedance probability forecast for Williamson River flows for June through September] + [Actual Flows that Occurred in March] + [Actual Flows that Occurred in April] + [Actual Flows that Occurred in May]

Considerable error remains in the Jun forecast in many years, rendering this variable most useful during the spring months.

3. Calculate **cum_Willdv**, the cumulative flow volume for the Williamson River from Mar 1 to the current day.

4. Calculate **Will_prop_cum**, which is yesterday's flow volume in the Williamson River as a proportion of the predicted Williamson River volume from today to Sep 30. Said another way, it is yesterday's Williamson River volume as a proportion of the expected volume to come.

$$\text{Will\_prop\_cum} = \frac{\text{Will\_Riv\_inf}_{-1}}{\text{Will50vol} - \text{cum\_Willdv}_{-1}}$$

5. Calculate **EWA_remain_JulSep**, which determines the EWA volume to be released from Link River Dam in July, August, and September. Computation:

   July: 0.35 * EWA_River – EWAuseddv_{-1}

   August: 0.49 * EWA_River – EWAuseddv_{-1}

   September: EWA_River – EWAuseddv_{-1}

6. Note **UKL_Oct1_level**, which is the UKL level on Oct 1 of each year. This variable tracks where the lake is starting from at the beginning of the water year, and is used in selecting the fill level target for that water year.

7. Calculate **Fill_level_target**, which will be used as a target in functions designed to encourage UKL filling during the spring. Extreme droughts begin with very dry winters. When UKL_cum_inf on Mar 1 < 450 TAF, then Fill_level_target = UKL_Oct1_level + 4 (this value is constrained to not exceed full pool, 4143.3 ft.). This step acknowledges that UKL is unlikely to fill in extreme droughts, so instead of targeting full pool as the fill level target, the target is selected to be 4 ft above the UKL level at the beginning of the water year. In all other years, Fill_level_target is set at full pool, 4143.3 ft.

8. Note **S1maxlvl**, which tracks the maximum UKL level attained each year. As UKL fills in the spring, each day this variable takes the value of S1yestelev (yesterday's UKL level). When UKL levels begin to decline, this variable retains the value of the highest UKL level attained.

9. Calculate **pastmaxUKLlvl**, a flag which equals 1 if S1maxlvl has been essentially constant for the previous 5 days, or if lake levels are declining. If not, it is set to equal 0, indicating that the lake is still filling.

10. Calculate **Fill_rate_ratio_spring**, which is a proportion expressing the relative progress of UKL levels towards filling. Computed as:

$$\text{Fill\_rate\_ratio\_spring} = \frac{\text{S1yestelev} - 4136\text{ ft}}{\text{Fill}_{\text{level}_{\text{target}}} - 4136\text{ ft}}$$

    This variable will gradually progress towards 1 as S1yestelev approaches the fill level target, and will be used to proportionally reduce Link releases to aid in filling UKL during the spring.

11. Calculate **EWAuseddv**, a cumulative variable which begins on Mar 1, and adds the daily increment of flow released as part of the EWA_River supply.

12. Look up **EWA_reserve**, which is a portion of EWA_River removed from potential use during the spring, retained for use during the base flow period. The reserved volume is looked up based on the EWA_River volume.

Table A.4.4.5.1 EWA Reserve

EWA_River (TAF)	EWA_reserve (TAF)
0	100
320	100
800	20
9999	20

13. Calculate **Net_LK_accrete**, which accounts for the inflows and outflows between Link River and Keno dams that will influence the amount of water flowing past Iron Gate Dam. Recall that outflows from Link River Dam are split into three flow arcs. The C1_ag arc includes releases of UKL water made expressly for agricultural diversions - these have nothing to do with releases made for Iron Gate flows and are not part of the Net_LK_accrete calculation. The C1_MIF and C1_EXC arcs both contain water that will go to Iron Gate Dam – accretions/depletions do not increase or diminish the volumes in these arcs, but they do increase or decrease the flows at Iron Gate. Highly variable accretions and depletions between Link and Keno dams create challenging conditions for an operation accounting for EWA releases at Link River Dam that are intended to produce adequate flow regimes at Iron Gate Dam. The Net_LK_accrete variable accounts for all pertinent accretions and depletions between Link and Keno dam, and is used to adjust Link River Dam releases. It could also be described as the Net_accrete variable (see A.4.4.1 – Fall/Winter Ops) without the Keno-to-IronGate component:

$$\text{Net\_LK\_accrete} = \text{C91\_F}_{-1} + \text{C131}_{-1} - \text{D11\_ss\_LRDC}_{-1} - \text{D12A\_ss\_LRDC}_{-1} + \text{I10}_{-1}$$

where:

$C91\_F_{-1}$ = Lost River Diversion Channel flow to the Klamath River

$C131_{-1}$ = flow into the Klamath River from pumps F and FF

$D11\_ss\_LRDC_{-1}$ = flow from the Lost River Diversion Channel routed to North Canal

$D12A\_ss\_LRDC_{-1}$ = flow from the Lost River Diversion Channel routed to Ady Canal

$I10_{-1}$ = Lake Ewauna accretions: net of ungauged inflows and outflows, and gauge error

-1 = the previous day

14. Set **IGmin**, which are minimum allowable flows at Iron Gate Dam. Intended only to provide a low-end control for Link Dam release calculations, minimum flow requirements are useful, and at times essential, for smoothly operating the system. Otherwise, operational rules are required that can account for and react to wide variations in accretions between Link and Iron Gate dams. No such rule is likely to adequately cover all possible situations. Conversely, in no way should minimum flow limits be interpreted as or converted into management targets. Such use of minimum flow specifications at Iron Gate Dam would be antithetical to the water management scheme embodied in the Proposed Action. Iron Gate minimum flow values are looked up from the IG limits table. In the event that the target Link dam release does not result in sufficient water to meet the Keno Dam release which is necessary to provide the IGmin flow at Iron Gate, a supplemental release is made from Link Dam through C1_EXC.

Table A.4.4.5.2 Monthly Iron Gate Minimum In-stream Flow

Month	**IG_MIF (cfs)**
October	1000
November	1000
December	950
January	950
February	950
March	1000
April	1150
May	1150
June	950
July	900
August	900
September	1000

15. Set **IG_max**, which is a maximum flow target at Iron Gate during Jul-Sep. In the event that calculations for Link releases would cause the flows at Iron Gate to exceed IG_max, the volume that would exceed IG_max is not released at Link River Dam, and is instead banked

for subsequent use during the Oct-Nov period. IG_max varies by month and by the magnitude of EWA_River.

Table A.4.4.5.3. Absolute Maximum Flow for the Klamath River by Month

July		**August**		**September**	
EWA_River (TAF)	**IG_max (cfs)**	**EWA_River (TAF)**	**IG_max (cfs)**	**EWA_River (TAF)**	**IG_max (cfs)**
0	1000	0	1050	0	1100
320	1000	320	1050	320	1100
1500	1500	1500	1250	1500	1350
9999	1500	9999	1250	9999	1350

16. Calculate **Link_release_for IGmax**, which is the approximate release from Link River Dam necessary to produce the IG_max flow at Iron Gate. Calculated only during Jul-Sep, this variable is used to determine the volume of EWA water, if any, that will be carried over into the Oct-Nov period.

$$\begin{aligned}\text{Link\_release\_forIGmax} \\ &= \text{IG\_max} - \text{C1\_EXC}_{-1} - \text{C91\_F}_{-1} - \text{C131}_{-1} + \text{D11\_ss\_LRDC}_{-1} \\ &+ \text{D12A\_ss\_LRDC}_{-1} - \text{I10}_{-1} - \text{I15}_{-1}\end{aligned}$$

where:

$\text{IG\_max} =$ maximum flow target during Jul – Sep at Iron Gate Dam

$\text{C1\_EXC}_{-1} =$ excess flow arc for releases from Link River Dam

$\text{C91\_F}_{-1} =$ Lost River Diversion Channel flow to the Klamath River

$\text{C131}_{-1} =$ flow into the Klamath River from pumps F and FF

$\text{D11\_ss\_LRDC}_{-1} =$ flow from the Lost River Diversion Channel routed to North Canal

$\text{D12A\_ss\_LRDC}_{-1} =$ flow from the Lost River Diversion Channel routed to Ady Canal

$\text{I10}_{-1} =$ Lake Ewauna accretions, net of ungauged inflows and outflows, and gauge error

$-1 =$ the previous day

17. Calculate **Releases from Link River Dam** through the C1_MIF arc (instream flows that are routed to Iron Gate Dam). Releases are smoothed over the first 4 days of each month with a weighted average of the flow on the last day of the previous month with calculated flow on the current day of the present month. This eases the transition between fall-winter and spring-summer operations, as well as smoothing changes associated with monthly changes in UKLsupply and EWA_River. **Note that unit conversions are not shown in these equations.**

Several objectives are achieved with the operational logic below. First, Link releases are shaped according to patterns in Williamson River flows during Mar-Jun. Setting aside the Fill_rate_ratio_spring and EWA_reserve variables for a moment, the equation for Mar-Jun below solves for $C1\_MIF_{-1}$ in the following equation:

$$\frac{\text{Will\_Riv\_inf}_{-1}}{\text{Will50vol} - \text{cum\_Willdv}_{-1}} = \frac{\text{C1\_MIF}_{-1} + \text{C1\_EXC}_{-1} + \text{Net\_LK\_accrete}_{-1}}{\text{EWA\_River} - \text{EWAuseddv}_{-1}}$$

The calculated $C1\_MIF_{-1}$ is used as the C1_MIF flow release in the current time step. The numerators each track daily flow volumes in either the Williamson River or in Link River Dam releases and Link to Keno accretions, whereas the denominators each track the remaining volume of the total Mar-Sep predicted (Williamson) or account (EWA) volumes.

This approach produces C1_MIF releases that will, when combined with C1_EXC and Net_LK_accrete volumes, produce flows at Keno Dam that echo the relative shape and magnitude of Williamson River flows. Further, it keeps Link releases on track to hit the EWA_River supply target. In addition, when spill or adherence to a minimum flow requirement causes releases in a time step that are not proportional to the Williamson side of the equation, they are accounted for in the next time step in the EWAuseddv variable, and the proper proportionality is restored. Of course, reliance on and reaction to events that happened the day previous means that the operator will always be chasing past events; nevertheless, this approach enables the operator to stay on track.

During Mar-May, the EWA_reserve volume is subtracted from EWA_River, with the intent of retaining this water for subsequent use during the summer. However, no volume is effectively reserved when UKL is spilling, or when releases at Link River Dam are being made to meet minimum flow requirements at Iron Gate Dam.

Finally, in most years the lake still needs to retain a substantial volume of inflow in order to fill, so the Fill_rate_ratio_spring variable is designed to keep UKL on a trajectory to fill. However, its influence decreases steadily as the lake fills. Reducing releases on the ascending limb of the UKL hydrograph functions to increase releases on the descending limb, which coincides with the onset of intensifying agricultural diversions that reduce Williamson River flows during May and June. In this way, the Fill_rate_ratio_spring simultaneously functions to help fill UKL and to redistribute water to produce a more normative hydrograph in the Klamath River.

$$\begin{aligned}\text{Mar to May Link\_release\_SS} &= \text{Fill\_rate\_ratio\_spring} * \text{Will\_prop\_cum} * (\text{EWA\_River} - \text{EWA\_reserve} \\ &\quad - \text{EWAuseddv}_{-1}) - \text{C1\_EXC}_{-1} - \text{Net\_LK\_accrete}_{-1}\end{aligned}$$

In June, filling UKL is no longer a concern, so the Fill_rate_ratio_spring variable is dropped. Since June marks the transition into the base flow period in most years, only half of the EWA_reserve volume is subtracted from EWA_River.

$$\begin{aligned}\text{Jun Link\_release\_SS} &= \text{Will\_prop\_cum} * (\text{EWA\_River} - 0.5 \\ &\quad * \text{EWA\_reserve} - \text{EWAuseddv}_{-1}) - \text{C1\_EXC}_{-1} - \text{Net\_LK\_accrete}_{-1}\end{aligned}$$

Finally, releases in Jul-Sep are comprised of either the average daily release for the monthly EWA volumes established by the EWA_remain_JulSep variable, or the Link_release_forIGmax variable, whichever is smaller. When Link_release_forIGmax is the smallest, the difference in volume is accumulated and carried over into the Oct-Nov period.

$$\text{Jul to Sep Link\_release\_SS} = \min\left(\text{Link\_release\_forIGmax}, \frac{\text{EWA\_remain\_JulSep}}{\text{daysinmonth}}\right)$$

18. Calculate **C1forC15**, which is the Link River Dam release target to maintain required flow at Iron Gate. C1forC15 = Link_release_SS, unless ramp rate restrictions result in higher flow.

19. Calculate **EWA_carryover**, which is the amount remaining of the EWA_River volume (if any) on Oct 1. Computed as EWA_River – EWAused_{-1}, the volume of water in EWA_carryover is divided by the 61 days in the Oct-Nov period to compute OctNov_augment, as discussed in A.4.4.1 (Fall/Winter ops).

A.4.4.6 EWA and Flood Control Releases

Flood control releases occur any time UKL would exceed the allowable flood control elevation under normal operations criteria (discussed further in Section A.4.4.8). During the irrigation season, these releases typically occur March through May during average to wet years, but can occur at any time of year depending on the rate of snow melt, fall and winter inflow and carry over storage in Upper Klamath Lake.

When releases are made for flood control during March through September, they are counted against the EWA and factored into future EWA releases. In some cases, the flood control releases can be so large that the remaining EWA volume would not be considered adequate to provide acceptable Klamath River fish habitat.

In order to protect against this scenario, a measure was added to ensure that the remaining EWA was enough to accommodate the minimum fish needs. This protection is considered whenever the total flood control releases have exceeded 22% of EWA_River by June 1. This measure ensures a certain volume of remaining EWA each month according to the following criteria:

1. If the total flood control releases that have occurred by June 1st exceed 22% of the EWA on June 1st, then the remaining EWA is reset to 25% of the total June 1st EWA.
2. If the total flood control releases that have occurred by July 1st exceed 22% of the EWA (as calculated on June 1st), then the remaining EWA is reset to 18% of the total EWA.
3. If the total flood control releases that have occurred by August 1st exceed 22% of the EWA (as calculated on June 1st), then the remaining EWA is reset to 13% of the total EWA.
4. If the total flood control releases that have occurred by September 1st exceed 22% of the EWA (as calculated on June 1st), then the remaining EWA is reset to 7% of the total EWA.

It is unlikely that spills will continue after June, however the potential for this does occur in very wet years where UKL remains full throughout the spring. The model results show that, when following this management plan, flood control releases do not occur in any year in the period of record after June.

A.4.4.7 Refuge Operation

There is no automatic project supply assigned to the refuge. Refuge delivery targets are determined by a combination of project supply and UKL storage conditions. The refuge can receive non-project water or a portion of the project supply, but not both.

1. The refuge has no target delivery March-May.
2. The refuge has no target delivery in June-July if the project supply is below 390 TAF.
3. In June through November, if the project has full supply (390 TAF) *and* if the UKL elevation is above the Threshold level denoted in Table A.4.4.7.1, the delivery target is set according to the monthly demand (also Table A.4.4.7.1). These deliveries are not counted against project supply, and they can be served from local accretions or UKL storage releases.
4. In August through November, if either the project supply is lower than 390 TAF or the UKL elevation is below the Table A.4.4.7.1 Threshold level, a portion of the remaining project supply can be reserved for refuge delivery, calculated by the following process.
   a. Calculate the remaining project supply on the first day of each month August-November.
   b. Define the fraction of the remaining project supply that is to be made available to the Refuge, **AugNovRfgFactor**, according to the table and plot shown in Figure A.4.4.7.1
   c. Determine the lake level adjustment threshold
      i. Aug-Sep – interpolate the UKL adjustment threshold using the Spring/Summer day counter (counts from March 1) and the associated thresholds in Table A.4.4.7.2
      ii. Oct-Nov – interpolate the UKL adjustment threshold using the water year day counter (counts from October 1) and the associated thresholds in Table A.4.4.7.2
   d. Calculate the lake level adjustment **UKL_rfg_adjust**, which reduces the project refuge supply when the UKL level gets too far below the threshold. If the UKL level is at or above the adjustment threshold, there is no adjustment, so UKL_rfg_adjust is 1.0. If the UKL level is .3 feet below the adjustment threshold, the project refuge supply gets turned off by setting UKL_rfg_adjust to 0.0. For UKL levels between the threshold and .3 feet below the threshold, the factor is interpolated between 1 and 0. UKL_rfg_adjust = 1.0 – min(0.3, max(0.0, UKL_rfg_adjust_thresh – UKL_level(-1)))/0.3
   e. Calculate the **RfgTgt_vol** (water volume available to be delivered to the refuge in the current month) as:
      RfrTgt_vol = Remaining Project Supply * AugNovRfgFactor * UKL_rfg_adjust

Table A.4.4.7.1 Monthly Refuge Demand and UKL Elevation Thresholds Which Condition Refuge Delivery

Month	Refuge Demand (TAF)	UKL Threshold (ft)
January	15.18	4139.0
February	11.53	4139.5
March	7.93	4140.0
April	7.93	4140.5
May	7.93	4141.5
June	0	4142.5
July	3.63	4143.0
August	5.28	4143.0
September	5.94	4142.5
October	6.93	4141.5
November	5.94	4140.5
December	17.16	4139.5

Table A.4.4.7.2 Upper Klamath Lake and Refuge Adjustment Threshold

SSdaynum (Aug-Sep)	UKL_level (ft)
154	4140.0
184	4139.1
214	4138.6
daynum (Oct-Nov)	**UKL_level (ft)**
1	4138.6
31	4138.6
61	4138.9

Month	Remaining Project Supply (taf)	Fraction Supply to Refuge
Oct	0	0
Oct	15	0
Oct	55	0.28
Oct	999	0.28
Nov	0	0
Nov	8	0
Nov	30	0.28
Nov	999	0.28
Aug	0	0
Aug	150	0
Aug	200	0.08
Aug	999	0.08
Sept	0	0
Sept	75	0
Sept	125	0.14
Sept	999	0.14

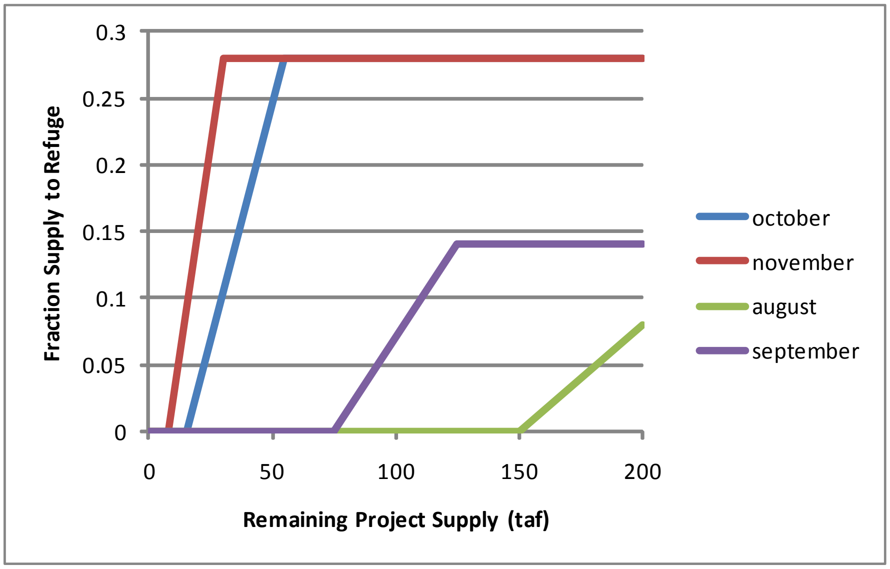


Figure A.4.4.7.1 Percentage of Remaining Project Supply to Refuge

A.4.4.8 Flood Control Operations

Flood control operations were implemented in order to protect the surrounding infrastructure at Upper Klamath Lake. The modeled flood control operations were developed to mimic realistic flood control operations; however real time management should be used in order to ensure safety and appropriate water management within UKL. The modeled operations manage the water during winter and early spring in a manner that prevents UKL from filling too early and remaining at or near full pool for several months in wetter years. The modeled flood control operations attempt to balance liability risk with risks associated with diminished water supplies for the Project, the Lower Klamath National Wildlife Refuges, and the Klamath River. Actual flood control releases will be made at the discretion of Reclamation and Pacificorp (the operator of Link River Dam.)

Outline of Flood Control Operations

The general process of flood control consists of spilling water from UKL when necessary to prevent elevations from increasing above threshold elevations, which change with time and forecasted inflows to UKL. These elevations are calculated each day to create a smooth UKL operation. These thresholds were designed to allow UKL fill by the end of March in drier years and by the end of April in wetter years.

The threshold elevations are determined through the following process:

1. The UKL threshold elevation is set at 4141.4 ft in September and October and then is steadily increased from 4141.4 ft to 4141.8 ft from November 1 through December 31. In most years, there are no flood control releases during these months.

2. From January 1 through April 30, the UKL threshold elevations are determined based on the forecasted inflow and the day of the month. The forecasted inflow is used to determine the end of month threshold elevation each month (using Table A.4.4.8.1 below) and the daily threshold elevation is linearly interpolated between the current end of month elevation and the previous month's end of month threshold elevation.
    a. The distinction between wet conditions and dry conditions in the table below is made based on the March through September 50% exceedance probability forecast that is issued by NRCS in January, February and March. The forecast issued in March is used for both March and April.
    b. The daily threshold elevation is calculated using the equation below:
    Current Threshold = [Yesterday's threshold value] + ([This month's threshold] – [Last month's threshold])/[Number of days in the month]
    Note: The threshold is intended to never decrease from day to day.

3. The UKL threshold elevations are maintained at the April 30th level from May 1 through August 31.

Table A.4.4.8.1 UKL Flood Release Threshold Elevations for the Last Day of Each Month Under Relatively Dry or Wet Conditions

Month	**Dry Condition Elevation (ft) (Forecast≤ 710 TAF)**	**Wet Condition Elevation (ft) (Forecast >710 TAF)**
October	4141.4	4141.4
November	4141.6	4141.6
December	4141.8	4141.8
January	4142.3	4142.0
February	4142.7	4142.4
March	4143.1	4142.8
April	4143.3	4143.3

A.4.4.9 Flow Ramping

Flow ramping at Iron Gate Dam

The following target ramp down rates at Iron Gate Dam, when possible, is as follows:

- When the flow at Iron Gate Dam is greater than 3,000 cfs: Ramp down rates will follow the rate of decline of total net inflows into UKL combined with accretions between Keno Dam and Iron Gate Dam.
- When Iron Gate Dam flows are above 1,750 cfs but equal to or less than 3,000 cfs: Decreases in flows of 300 cfs or less per 24-hour period, and no more than 125 cfs per four-hour period.
- When Iron Gate Dam flows are 1,750 cfs or less: Decreases in flows of 150 cfs or less per 24-hour period and no more than 50 cfs per two-hour period.

Upward ramping was not restricted.

The WRIMS model does not include operations of storage capacity within the PacifiCorp facilities. Therefore the model is only able to adjust Link River Dam releases to attempt to comply with the ramping rate restrictions assumed.

Link River Dam releases cannot necessarily be adjusted to comply with the ramping rate restrictions if unregulated flows are present at Link River Dam or Iron Gate Dam.
The WRIMS model recognizes when these unregulated flow conditions exist and, under those conditions, does not attempt to comply with the ramping rate restrictions.

Table A.4.4.2.1 Elevation Storage-Area

Storage (TAF)	Area	Elevation (ft)
0	46229	4136.0
5	47243	4136.1
9	48458	4136.2
14	49674	4136.3
19	50991	4136.4
25	52309	4136.5
30	53628	4136.6
35	54947	4136.7
41	56068	4136.8
47	56990	4136.9
52	58012	4137.0
58	58935	4137.1
64	59860	4137.2
70	60585	4137.3
76	61310	4137.4
82	61937	4137.5
89	62600	4137.6
95	63263	4137.7
101	63927	4137.8
108	64592	4137.9
114	65157	4138.0
121	65842	4138.1
127	66407	4138.2
134	66973	4138.3
141	67339	4138.4
148	67610	4138.5
154	67800	4138.6
161	68089	4138.7
168	68377	4138.8
175	68664	4138.9
182	68950	4139.0

Storage (TAF)	Area	Elevation (ft)
189	69629	4139.1
196	69813	4139.2
203	71108	4139.3
210	71190	4139.4
217	71371	4139.5
224	71451	4139.6
231	71629	4139.7
239	71707	4139.8
246	71883	4139.9
253	71958	4140.0
260	73741	4140.1
268	73914	4140.2
275	73985	4140.3
282	74056	4140.4
290	74125	4140.5
297	74292	4140.6
305	74359	4140.7
312	74424	4140.8
320	74488	4140.9
327	74550	4141.0
335	78826	4141.1
343	78885	4141.2
351	78944	4141.3
359	79001	4141.4
367	79156	4141.5
374	79211	4141.6
383	82507	4141.7
391	82558	4141.8
399	82708	4141.9
408	82756	4142.0
416	82803	4142.1
424	82848	4142.2
432	82892	4142.3
441	83034	4142.4
449	83075	4142.5
457	83114	4142.6
466	83151	4142.7
474	83287	4142.8
482	83321	4142.9
491	83354	4143.0
499	83385	4143.1
507	83514	4143.2
516	83542	4143.3
524	83568	4143.4

Storage (TAF)	Area	Elevation (ft)
532	83592	4143.5

Section A: Key Model Variables

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
A2RFF	Area A2 Return Flow Factor	Factor to calculate return flows from the A2 area - 30% of deliveries in Spring/Summer and 40% of deliveries in Fall/Winter	AgRefOps.wresl
C1	Link River Dam Release	Total Link River flow released out of Link River Dam from Upper Klamath Lake	Channel-table.wresl
C1_AG	Link River Ag Release	Link River flow released out of Link River Dam for agricultural or LKNWR deliveries only	Channel-table.wresl
C1_EXC	Link River Flood Release	Link River flow released out of Link River Dam for flood control only	Channel-table.wresl
C1_MIF	Link River EWA Release	Link River flow released out of Link River Dam for River flows (fish flows) only. This volume cannot be diverted for agricultural or LKNWR use.	Channel-table.wresl
C10	Klamath River Flow	Flow upstream of North Canal on the Klamath River	Channel-table.wresl
C11	Klamath River Flow	Flow between North Canal and Ady Canal on the Klamath River	Channel-table.wresl
C12	Klamath River Flow	Flow downstream of Ady Canal on the Klamath River	Channel-table.wresl
C13	Klamath River Flow	Flows upstream of Keno Reservoir on the Klamath River	Channel-table.wresl
C131	Straits Drain flow (or Pumping Plant F/FF)	Return flows and runoff from the A2 area and LKNWR that are pumped through pumping plant F/FF	Channel-table.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
C14	Keno Flow	Flow downstream of Keno Reservoir and upstream of Iron Gate Reservoir on the Klamath River	Channel-table.wresl
C15	Iron Gate Flow	Flow downstream of Iron Gate Reservoir on the Klamath River	Channel-table.wresl
C9	Klamath River Flow	Flow in the Klamath River downstream of the Lost River Diversion Channel inflow point	Channel-table.wresl
D1	A Canal Deliveries	A Canal project deliveries to area A1	Delivery-table.wresl
D11	North Canal Deliveries	North Canal Project Deliveries to area A2	Delivery-table.wresl
D12	Ady Canal flow	Ady Canal flow to either Area A2 (including the Area K lease lands) or the Lower Klamath National Wildlife Refuge	Delivery-table.wresl
D12A	Ady Canal Ag Flow	Ady Canal flow to project in Area A2	Delivery-table.wresl
D12B	Ady Canal Refuge Flow	Ady Canal flow to the Lower Klamath National Wildlife Refuge	Delivery-table.wresl
D91	Station 48/Miller Hill Deliveries	Lost River Diversion Channel project deliveries through the Station 48 diversion and Miller Hill Pumping Plant	Delivery-table.wresl
I1	UKL Net Inflow-averaged	Net Inflow into Upper Klamath Lake (calculated as the change in storage plus releases through A Canal and Link River Dam). This is added as a 3 day average to minimize the effects of wind on perceived storage levels.	Inflow-table.wresl
I1_raw	UKL Net Inflow-raw	Net Inflow into Upper Klamath Lake (calculated as the change in storage plus releases through A Canal and Link River Dam). This is added as a raw value and includes errors from wind.	Inflow-table.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
I10	Lake Ewauna Accretions	Lake Ewauna Accretions - difference between historical flows released out of Link River Dam minus known diversions and the measured flow upstream of Keno Reservoir. Diversions include LRDC which may flow into the Klamath River as an inflow.	Inflow-table.wresl
I131	A2 Winter Runoff	Runoff and/or losses in the system along Straits Drain. Calculated as the known pumped values at pumping plants F/FF minus all the known inputs into Straits Drain.	Inflow-table.wresl
I15	Keno to Iron Gate Accretions	Keno to Iron Gate Accretions - difference between historical flows released out of Keno Dam and flow releases out of Iron Gate Reservoirs	Inflow-table.wresl
I91	LRDC at Wilson	Flow from the Lost River that was diverted into the Lost River Diversion Channel at Wilson Dam	Inflow-table.wresl
R131a	Area A2 Return Flows	Return flows from the A2 area - 30% of deliveries in Spring/Summer and 40% of deliveries in Fall/Winter	Return-table.wresl
R131b	Refuge Return Flows	Return flows from the Lower Klamath National Wildlife Refuge	Return-table.wresl
S1	Upper Klamath Lake Storage	Upper Klamath Lake Storage (TAF)	Reservoir-table.wresl
S1_1	Upper Klamath Lake Storage	UKL bottom storage = 10 TAF	Reservoir-table.wresl
S1_2	Upper Klamath Lake Storage	UKL storage from 10 TAF to the storage at elevation 4137.0 ft.	Reservoir-table.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
S1_3	Upper Klamath Lake Storage	UKL Storage from elevation 4137.0 ft to the flood control limit (UKL_flood_lvl)	Reservoir-table.wresl
S1_4	Upper Klamath Lake Storage	UKL Storage from the flood control limit to the maximum value of 593 TAF	Reservoir-table.wresl
UKL_flood_lvl	Flood Control Elevation Limit	Maximum flood control elevation determined based on hydrologic conditions	Res_Reqs.wresl
UKL_flood_sto1	Flood Control Storage Limit	Storage associated with the Maximum flood control elevation for May-Sep. This is currently set at an elevation of 4143.1 ft.	Res_Reqs.wresl
UKL_min_lvl	UKL Minimum	The minimum elevation of 4137.0 ft. Note: this variable is merely a WRIMS modeling artifact – used to define the bottom level of a layer of storage in UKL and not as a target or aspect of lake operation.	Res_Reqs.wresl
UKL_min_sto	UKL Minimum Storage	Storage volume associated with the minimum elevation of UKL_min_lvl.	Res_Reqs.wresl
A1calc	Project Supply for Area A1	Portion of the project supply that is expected to go to area A1. This volume is calculated based on typical percentages shown in the historical use patterns.	AgRefOps.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
A2FW	KDD State Water Right	Area A2 Fall Winter minimum supply of 19.224 TAF. This is the KDD State Water Right for Oct-Feb and is an amount that must be delivered through D11 and D12A before any "project water" (identified by FWavail) is delivered. Due to the prior water right, this is essentially a guaranteed delivery to D12A every year. This amount is typically used by mid-December.	Definitions.wresl
AdyHistOF	Ady Canal Ag Demand	Historical Project diversions to Ady from Oct-Feb of each year. These are used to represent full demand.	AgRefOps.wresl
AgAllocRemain	Remaining Ag Supply	Current remaining Project supply at the specified point in time.	SeasonalSupply.wresl
AgHistRemain	Remaining Demand	Remaining un-met demand for Project deliveries as compared to historical demand.	SeasonalSupply.wresl
AgRemain	Unused Project supply	Remaining spring-summer supply, able to be used through November 30th. In Oct-Nov, this volume must be used only for demands in area A1 which is through A canal (D1) and Station 48/Miller Hill (D91). Ag deliveries through North and Ady Canal receive water through either their state water right (A2FW) or the Fall/Winter project water (FWavail).	SeasonalSupply.wresl
AIL	Available Inflow Above Link	Available inflow above Link Dam which is equal to the net inflow that occurred yesterday (I1)	FallWinterRiverOps.wresl
Apr50	April forecast	April 1st 50% exceedance probability net inflow forecast for April through September to Upper Klamath Lake	Definitions.wresl
C13_MIF	Minimum Flow @ Keno	Minimum amount that must be released downstream of Keno in order to meet the absolute minimum flow at Iron Gate. (IG_mif)	Channel-table.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
C1forC15	Link River Dam Release Target	Link River Release to maintain minimum required flow at Iron Gate Site	UKLReleases.wresl
C91	LRDC to Klamath	Link between the Lost River and Klamath River (Lost River Diversion Channel). C91 is a two-way link, as flows can go both ways. If C91 is positive, C91_F (forward) has a value and the flow reflects water traveling from the Lost River to the Klamath River. If C91 is negative, C91_R has a value and the flow reflects a delivery of Klamath River water to Station48/Miller Hill	Channel-table.wresl
cum_month_rfg	Monthly Refuge Delivery	Monthly cumulative refuge delivery, reset each month.	AgRefOps.wresl
CumAg_ss_Del	Spring-Summer delivery	Track the cumulative Ag spring-summer deliveries from UKL to compute remaining Project supply, which is one limit on project delivery	SeasonalSupply.wresl
CumAg_ss_Div	Spring-Summer diversion	Track the cumulative Ag spring-summer diversions (MAR-NOV) for comparison to the historical demand. This includes all diversions regardless of whether they come from LRDC or UKL.	SeasonalSupply.wresl
cum_Willdv	Cumulative Williamson Inflow	Tracks cumulative flow in Williamson River below Chiloquin March through September	UKL_Releases.wresl
D_KDD	Diversion to KDD	Diversion to KDD through North and Ady Canals. In the mode, this formula = D11 + D12A.	Delivery-table.wresl
D1_target	Project Supply for A Canal	A Canal's portion of the project supply	Delivery-table.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
D1_surp	Delivery Surplus	The difference between A canal's defined portion of the supply and what the model delivers to A canal. In some cases, there may be remaining supply and remaining historical demand, but due to the percent distributions of each area, there is no place to put the flow. In this case, it is diverted to the A canal through D1_surp.	Delivery-table.wresl
D11_fw	North Canal fall winter diversion	North Canal fall winter diversion	Delivery-table.wresl
D11_hist_lim	North Canal historical limit	North Canal historical limit	AgRefOps.wresl
D11_KDDReserve_lim	North Canal KDD Reserve	North Canal's portion of the KDD Reserve volume for the Fall/Winter period due to their state water right. The total reserved volume is 19.234 TAF. See definition for A2FW.	AgRefOps.wresl
D11_ss	North Canal Deliveries	Calculated North Canal delivery to KDD, regardless of source from March 1 - September 30th	Delivery-table.wresl
D11_ss_LRDC	North Canal Deliveries from LRDC	North Canal Spring-Summer delivery from LRDC from March 1 - September 30th	Delivery-table.wresl
D11_ss_UKL	North Canal Deliveries from UKL	North Canal deliveries from UKL (from the supply) for March 1 - September 30th	Delivery-table.wresl
D11_surpl_lim	North Canal Deliveries Limit	North Canal (KDD) fall-winter surplus limit	AgRefOps.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
D11calc	North Canal Deliveries	Calculated North Canal (to KDD) diversion - this is the amount the model expects to be delivered unless an unexpected constraint on water supply occurs. The actual delivery is expressed in D11.	AgRefOps.wresl
D12A_fw	KDD Deliveries	Fall-Winter delivery to KDD	Delivery-table.wresl
D12a_hist_lim	KDD Deliveries	historical limit of delivery to KDD	AgRefOps.wresl
D12a_KDDReserve_lim	KDD Deliveries	KDD fall-winter water right limit as applied at Ady Canal	AgRefOps.wresl
D12A_ss	KDD Deliveries	Ady Canal Ag delivery from March 1 - September 30	Delivery-table.wresl
D12A_ss_calc	KDD Deliveries	Expected Ady Canal delivery to KDD regardless of source from March 1 to September 30	AgRefOps.wresl
D12A_ss_LRDC	KDD Deliveries	Ady Canal spring-summer supply from LRDC	Delivery-table.wresl
D12A_ss_UKL	KDD Deliveries	Ady Canal spring-summer supply from UKL	Delivery-table.wresl
D12a_surpl_lim	KDD Deliveries	Ady Canal (KDD) fall-winter surplus limit	AgRefOps.wresl
D12Acalc	KDD Deliveries	Calculated Ady Canal Ag (to KDD) diversion - this is the amount the model expects to be delivered unless an unexpected constraint on water supply occurs. The actual delivery is expressed in D12A.	AgRefOps.wresl
D12B_FallWet	Refuge Deliveries	Amount of D12B supplied to Fall-Seasonal Wetlands	AgRefOps.wresl
D12B_FallWetcumul	Refuge Deliveries	Cumulative supply to Fall Seasonal Wetlands	AgRefOps.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
D12B_PermWet	Refuge Deliveries	Amount of D12B supplied to Permanent Wetlands	AgRefOps.wresl
D12B_PermWetcumul	Refuge Deliveries	Cumulative supply to permanent wetland	AgRefOps.wresl
D12B_WintWet	Refuge Deliveries	Amount of D12B supplied to Winter Wetlands	AgRefOps.wresl
D12B_WintWetcumul	Refuge Deliveries	Cumulative supply to Winter Wetlands	AgRefOps.wresl
D12Bcalc	Refuge Deliveries	Calculated Ady Canal Refuge (to LKNWR) diversion - this is the amount the model expects to be delivered unless an unexpected constraint on water supply occurs. The actual delivery is expressed in D12B.	AgRefOps.wresl
D1calc	A Canal deliveries	Calculated A Canal delivery - this is the amount the model expects to be delivered unless an unexpected constraint on water supply occurs. The actual delivery is expressed in D1.	AgRefOps.wresl
D91calc	Lost River Deliveries	Calculated delivery through to Station 48 and Miller Hill pumping plants (D91) - this is the amount the model expects to be delivered unless an unexpected constraint on water supply occurs. The actual delivery is expressed in D91.	AgRefOps.wresl
daynum	Counter of Days	Day number in fall and winter (Oct 1 = 1, Feb 28=152)	Definitions.wresl
daysinprevmo	Number of Das	number of days in the previous month	Res_Reqs.wresl
dem_D1_ss_hist	Area 1 demands	Area 1 Spring-Summer historical demand limit on A canal	AgRefOps.wresl
dem_D11_ss_hist	Area 2 demands	KDD Spring-Summer historical demand limit on North Canal	AgRefOps.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
dem_D12A_ss_hist	Area 2 demands	KDD Spring-Summer historical demand limit on Ady Canal	AgRefOps.wresl
dem_D91_ss_hist	Area1 demands	Area A1 spring-summer historical demand limit on LRDC diversions	AgRefOps.wresl
Diff_thresh	Threshold	The threshold in which the distribution type may have changed from one forecast to the next. This affects the EWA distribution pattern.	UKLReleases.wresl
DT	Distribution type	Distribution type - 1 through 5 where type 1 is dry and type 5 is wet and is determine based on the March 50% exceedance forecast	Definitions.wresl
EOStgt	End of September Target Elevation	End of September Elevation Target - linearly interpolated between 4138.1 ft and 4138.75 ft based on the value of Mar50Vola "wet" value and a "dry" value (currently 4138 ft and 4139 ft respectively)	Res_Reqs.wresl
EOStgtsto	End of September Target Storage	Storage associated with an End of September Elevation Target - linearly interpolated between a "wet" value and a "dry" value	Res_Reqs.wresl
EWA_River	EWA	The Environmental Water Account that can only go to the River (not for diversions)	SeasonalSupply.wresl
EWARemain	Remaining EWA	The remaining Environmental Water Account between now and the end of September	SeasonalSupply.wresl
EWA_remain_JulSep	Remaining EWA for July-Sept	On the first day of July-September, monthly portions of the remaining EWA are designated for use in that month. These values are July-35%, August-44%, and September-100%.	UKLReleases.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
EWARemainMinimum	Remaining EWA	The minimum EWA remaining values as a function of the total EWA to protect against low summer flows as a result of high flood control releases. These percentages are only used when the spills use too much of the EWA. If spills do not exceed 22% of the EWA, these restrictions are not used.	SeasonalSupply.wresl
EWA_reserve	EWA Reserve	Portion of the EWA_River volume which is to be reserved for use later in the summer.	UKL_Releases.wresl
EWA_Used	EWA Used	Cumulative releases from Link River Dam from March 1 through September 30 counted as release of EWA water	SeasonalSupply.wresl
FallWetrtrn	Fall-Winter return	Fall seasonal wetland return flow calculation	AgRefOps.wresl
FallWetrtrncumul	Fall-Winter return accumulator	Cumulative Fall seasonal wetland return flow	AgRefOps.wresl
Fill_rate_diff	difference of UKL fill rate	The differences between UKL fill rate needed to reach 4142.8ft on May 1 and the fill rate in the past 7 days during fall-winter operation	FallWinterRiverOps.wresl
Flood50fc	Inflow Forecast	March through September 50% exceedance UKL inflow forecast that was issued each January, February and March. The April value is equal to forecast from March. This value is used to set the flood control elevations.	Res_Reqs.wresl
FSpct	Wetland Portion of LKNWR Delivery	Percent of LKNWR delivery for fall-seasonal wetlands	AgRefOps.wresl
FSrtrnpct	Wetland Return	Percent of return from fall-seasonal wetlands	AgRefOps.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
FWavail	Project Water in the Fall and Winter	The amount of water available for UKL storage, project deliveries and refuge deliveries (D11, D12A, and D12B) for Oct through Feb.	FallWinterRiverOps.wresl
IG_mif	Absolute Minimum Iron Gate Flow	Hard Iron Gate minimum. This is a hard Iron Gate minimum flow set for Oct-Feb only	Channel-table.wresl
int_C91	Integer Switch	Integer switch represents the flow direction in Lost River Diversion Channel. When this value = 1. the LRDC is flowing to the Klamath River. When the value is 0, the LRDC is flowing from the Klamath River and into Station 48 and Miller Hill pumping plants to deliver irrigation water.	Channel-table.wresl
Jun50	Inflow Forecast	June 50 percentile exceedance probability forecast for June - September UKL net inflows	Definitions.wresl
KDDReserve	Remaining KDD delivery	Unused KDD state water right from Oct through Feb. KDD cannot use "project water" until this amount is 0. Note: this value is not considered in any supply calculation - it is only used to determine whether or not they are at their state water right limit or not.	FallWinterSupply.wresl
LastMonthInf	Last Month Inflow	The inflow that came in during the previous month.	Res_Reqs.wresl
lim_D1_alloc	A Canal Deliveries	A Canal and Sta48 demands (these will only have values March-Sept)	AgRefOps.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
lim_I131_neg	Area A2 Winter Runoff	Area A2 winter runoff when negative (if positive, then value is 0)	Connectivity-table.wresl
lim_I131_pos	Area A2 Winter Runoff	Area A2 winter runoff, positive	Connectivity-table.wresl
Link_max	Maximum flow@Link River Dam	Maximum flow through Link River Dam currently set at 9200 cfs.	FallWinterRiverOps.wresl
Link_min	Minimum flow@Link River Dam	Minimum flow through Link River Dam currently defined as 200 cfs except when defined through the Link_min table Oct-Feb.	FallWinterRiverOps.wresl
Link_WF_target	Link Release Target	Link release target for the River only during the Fall-Winter period. It is equal to the maximum of the minimum Link release, Link_release_FW, or the release required to maintain the minimum required IG flow	FallWinterRiverOps.wresl
Mar50	Forecasted Mar-Sep Inflow	March 1st 50% exceedance forecast for March through September	Definitions.wresl
Mar50vol	Forecasted Mar-Sep Inflow	Forecasted UKL Supply. Mar 1 = Mar-Sept forecast, Apr 1 = Apr-Sep forecast + actual March inflow May 1=May-Sep forecast+actual March and April Inflow June 1=Jun-Sep forecast+actual March, April, and May inflow July-Sept = value from June	Res_Reqs.wresl
May50	Inflow Forecast	May 1st 50% exceedance forecast for March through September	Definitions.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
Needed_fill_rate	UKL Fill Rate	The average fill rate necessary to fill UKL to an elevation of 4142.8 ft on May 1 based solely on a linear calculation between the current elevation and 4142.8 ft and the number of days till May 1st.	FallWinterRiverOps.wresl
NorHistOF	Historical North Canal Delivery	Historical North Canal deliveries October through February (volume in TAF)	AgRefOps.wresl
NS_Forecast	Forecasted Supply	Forecasted supply from current month through SEPTEMBER	SeasonalSupply.wresl
pctA1	A1 Ag Percentage	% of total Ag supply (Mar-Sept) that goes to area A1	AgRefOps.wresl
pctA1rem	A1 Ag Percentage	% of remaining Ag supply (Mar-Sept) that goes to area A1	AgRefOps.wresl
pctA2	A2 Ag Percentage	% of total Ag supply (Mar-Sept) that goes to area A2	AgRefOps.wresl
pctA2rem	A2 Ag Percentage	% of remaining Ag supply (Mar-Sept) that goes to area A2	AgRefOps.wresl
pctACan	A Canal Ag percentage	% of A1 supply (Mar-Sept) that goes to the A canal (D1)	AgRefOps.wresl
pctACanrem	A Canal Ag percentage	% of remaining A1 supply (Mar-Sept) that goes to the A canal (D1)	AgRefOps.wresl
pctAdyAg	Ady Ag percentage	% of A2 supply that goes to Ady Canal for Ag only	AgRefOps.wresl
pctD11mon	North Canal Ag percentage	% of total North Canal Ag (D11) portion of the supply that is used in each month (even distributed across the month)	AgRefOps.wresl
pctD11mon_rem	North Canal Ag percentage	% of remaining North Canal Ag (D11) portion of the supply that is used in each month (even distributed across the month)	AgRefOps.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
pctD12Amon	Ady Canal Ag percentage	% of total Ady Canal Ag (D12A) portion of the supply that is used in each month (even distributed across the month)	AgRefOps.wresl
pctD12Amon_rem	Ady Canal Ag percentage	% of remaining Ady Canal Ag (D12A) portion of the supply that is used in each month (even distributed across the month)	AgRefOps.wresl
pctD1mon	A Canal Ag percentage	% of total A Canal (D1) portion of the supply that is used in each month (even distributed across the month)	AgRefOps.wresl
pctD1mon_rem	A Canal Ag percentage	% of remaining A Canal (D1) portion of the supply that is used in each month (even distributed across the month)	AgRefOps.wresl
pctD91mon	Lost River Ag percentage	% of total Station 48/Miller Hill (D91) portion of the supply that is used in each month (even distributed across the month)	AgRefOps.wresl
pctD91mon_rem	Lost River Ag percentage	% of remaining Station 48/Miller Hill (D91) portion of the supply that is used in each month (even distributed across the month)	AgRefOps.wresl
pctKDDsurFW	KDD Inflow Percentage	% of the daily inflow that goes to KDD up to their historical use - can only be used after their state water right is used and total use cannot exceed historical use.	AgRefOps.wresl
pctLRDC	Lost River Ag percentage	% of A1 supply that goes to the Station 48/Miller Hill (D91)	AgRefOps.wresl
pctLRDCrem	Lost River Ag percentage	% of remaining A1 supply that goes to the Station 48/Miller Hill (D91)	AgRefOps.wresl
pctNorth	North Canal Ag percentage	% of A2 project supply that goes to North Canal	AgRefOps.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
pctRfgsurFW	Refuge Inflow Percentage	% of the daily inflow that goes to the Refuge in the fall and winter.	AgRefOps.wresl
PermWetrtrn	Permanent Wetland return flow	Permanent Wetlands return flow calculation	AgRefOps.wresl
PermWetrtrncumul	Permanent Wetland return flow	Cumulative Permanent Wetlands return flow	AgRefOps.wresl
PrjSupply	Project Supply	Project supply for area A1 and A2. For area A1, the project supply can be used March - November and for area A2, the project supply can be used March through September.	SeasonalSupply.wresl
prjhistuse	Historical Ag Demand	The historical Spring/Summer actual project delivery. For area A1, this is calculated March - November and for area A2, it is calculated as March through September. Water bank volumes were included for 2001-2011 to better represent full demand.	Definitions.wresl
projectmax	Maximum Project Supply	Maximum project supply volume from UKL only. Actual maximum deliveries = projectmax+LRDC Contribution. This value is used to limit the project supply.	Definitions.wresl
PWpct	Permanent Wetland Delivery percentage	Percent of LKNWR deliveries for permanent wetlands	AgRefOps.wresl
PWrtrnpct	Permanent Wetland return percent	Lookup percent of return flow (dependent on month and accumulative supply in a time-frame)	AgRefOps.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
Recent_fill_rate	UKL Fill Rate	Average UKL fill rate for the Last 7 days	FallWinterRiverOps.wresl
rem_rfg_month_dem	Remaining Refuge Demand	Remaining refuge demand each month	AgRefOps.wresl
rem_supply_dec	Remaining supply decrease	Tracks the change in UKL supply due to the May and June forecasts. If it has a value then the supply decreases.	SeasonalSupply.wresl
rem_supply_inc	Remaining supply increase	Tracks the change in UKL supply due to the May and June forecasts. If it has a value then the supply increases.	SeasonalSupply.wresl
Rfg_month_dem	Refuge monthly demand	Refuge monthly demand	AgRefOps.wresl
Rfgtgt_vol	Target Refuge Volume	A portion of the remaining Project supply that is assigned to Refuge delivery in August-November under certain conditions.	SeasonalSupply.wresl
S14	Keno Reservoir Storage	Keno Reservoir storage. This is a modeling artifact only to account for travel time. The storage volume was developed with no relationship to the actual Keno Reservoir.	Reservoir-table.wresl
S1yestelev	UKL Yesterday's Elevation	UKL yesterday's elevation	SeasonalSupply.wresl
sum_ag_dem_ss	Total Demand	Tracking total demand for later calculation of remaining demand.	AgRefOps.wresl
UKL_cum_inf	UKL Cumulative Inflow	UKL cumulative inflow between September and April	Res_Reqs.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
UKL_cum_inf_ind	UKL Cumulative Inflow Index	Normalized index which tracks cumulative inflow relative to the same day over the period of record.	FallWinterRiverOps.wresl
UKL_flood_sto	UKL Flood Storage	UKL flood storage - no storage is available above this value for March through September	Res_Reqs.wresl
UKL_release_level_ som_use	UKL Release Level	Maximum UKL flood release threshold at the start of each month. This is either the calculated start of month level (UKL_release_lvl_SOM) or the flood elevation from the last day of the previous month (UKL_release_thresh), whichever is bigger	Res_Reqs.wresl
UKL_release_lvl	UKL Release Level	UKL release level, derived from UKL_release_sto using rating curve, linear interpolated.	Res_Reqs.wresl
UKL_release_lvl_eom	UKL Release Level	Maximum UKL flood release threshold at the end of each month. This is equal to the early_flood_lvl variable (4142.0 ft) for October through December and is determined based on the March through September inflow forecast along with a look up table of monthly values from January to April.	Res_Reqs.wresl
UKL_release_lvl_som	UKL Release Level	Maximum UKL flood release threshold at the start of each month. This is equal to the early_flood_lvl variable (4142.0 ft) for October through December and is determined based on the March through September inflow forecast along with a look up table of monthly values from January to April.	Res_Reqs.wresl
UKL_release_sto	UKL Release Storage	UKL storage associated with UKL release threshold	Res_Reqs.wresl
UKL_release_thresh	UKL Release Level	Maximum UKL flood release threshold (elevation) each day. This is linearly interpolated between the start of month and end of month thresholds (UKL_release_lvl_som_use and UKL_release_lvl_eom)	Res_Reqs.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
UKL_release_thresh_sto	UKL Release Storage	UKL Storage associated with UK_release_thresh	Res_Reqs.wresl
UKLSupply	UKL Supply	End of Feb storage + Mar-Sept forecasted inflow - End of September storage target. Calculated on Mar 1, April 1, May 1 and June 1. The Mar-Sept forecasted inflow is the Mar50vol variable described previously.	SeasonalSupply.wresl
Will_Riv_inf	Williamson River Inflow	Williamson River gage below Chiloquin	Inflow-Table.wresl
Will_prop	Williamson River Proportion	The proportion of yesterday's Williamson River Inflow to target for release to the river in Fall/Winter	FallWinterRiverOps.wresl
Will_prop_cum	Cumulative Williamson River Proportion	Proportion of previous day's Williamson River inflow relative to the remaining expected Williamson River inflow through September	UKLReleases.wresl
Will50vol	Forecasted March-Sept Inflow	Estimate of total March-September Williamson River Inflow volume, calculated from a combination of actual observed flow and forecasted inflows as data is available	UKLReleases.wresl
Will_Mar50 Will_Apr50 Will_May50 Will_Jun50	50% exceedence forecasts	NRCS 50% exceedence forecasts for Williamson River below Chiloquin. Feb & Mar forecasts are for Mar-Sep total; Apr-Jun forecasts are for that month through September.	UKL_Releases.wresl
WintWetrtrn	Winter Wetland Return	Winter seasonal wetland return flow calculation	AgRefOps.wresl
WintWetrtrncumul	Winter Wetland Return	Cumulative Winter wetland return flow	AgRefOps.wresl

Table A.4.3.4.1 Key Model Variables

Variable Name in Model code	Common Name	Definition	Model File of Initial Definition
WWpct	Percent of supply for winter wetlands	Percent of supply for winter wetlands	AgRefOps.wresl
WWrtrnpct	Percent of return from winter wetlands	Percent of return from winter wetlands	AgRefOps.wresl

Section B: Proposed Action Model Output Graphs

Iron Gate Dam flows and Upper Klamath Lake elevations from water year 1981 to 2011 were modeled as part of the biological assessment. Figures B1-B11, shown below, compares the modeled values to historical measurements. The modeling results are intended to help assess the impact of proposed operations (previously described) on fisheries by comparing how this operation would have changed historically observed flows in the Klamath River downstream of Iron Gate Dam and elevations at Upper Klamath Lake.

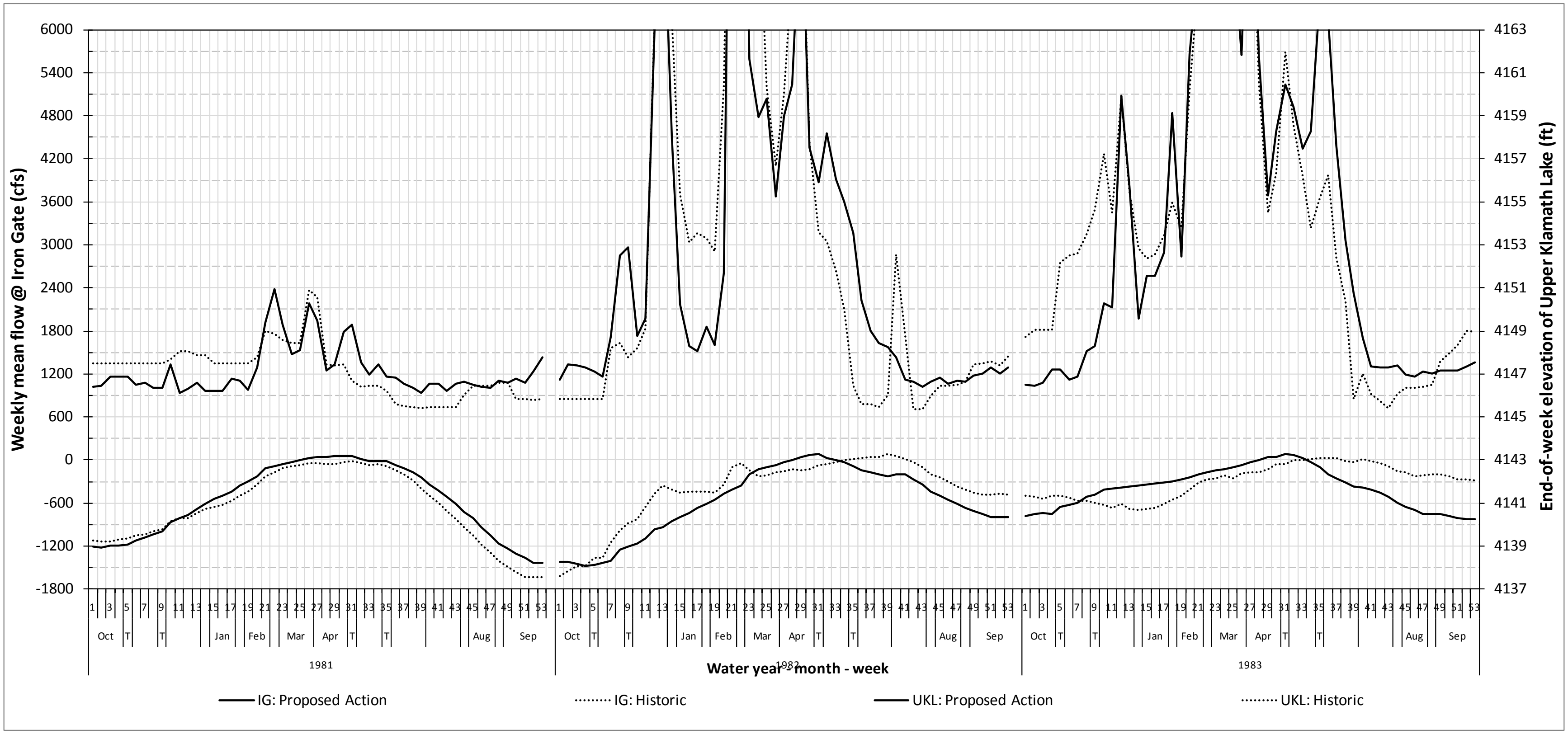


Figure B1. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (1981-1983)

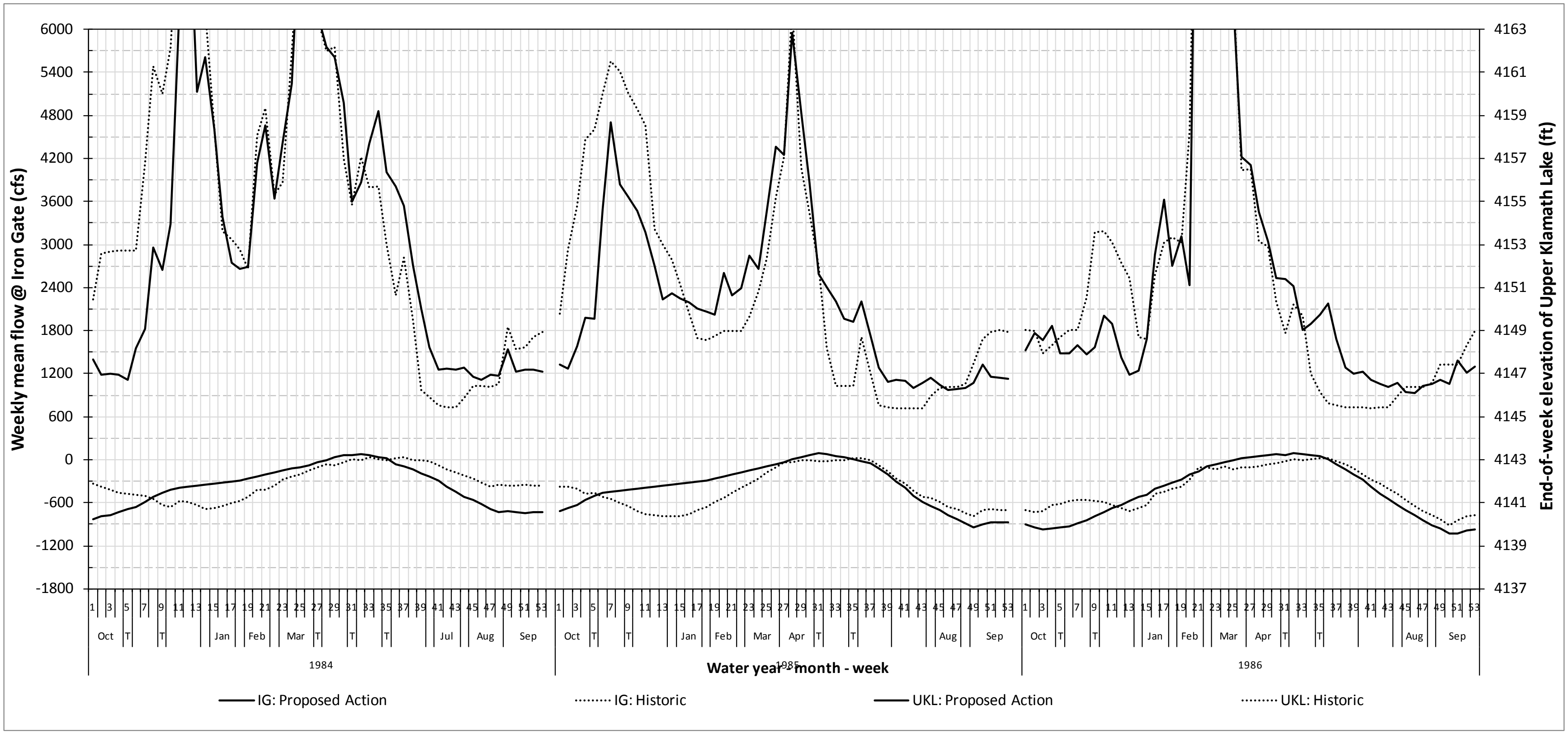


Figure B2. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (1984-1986)

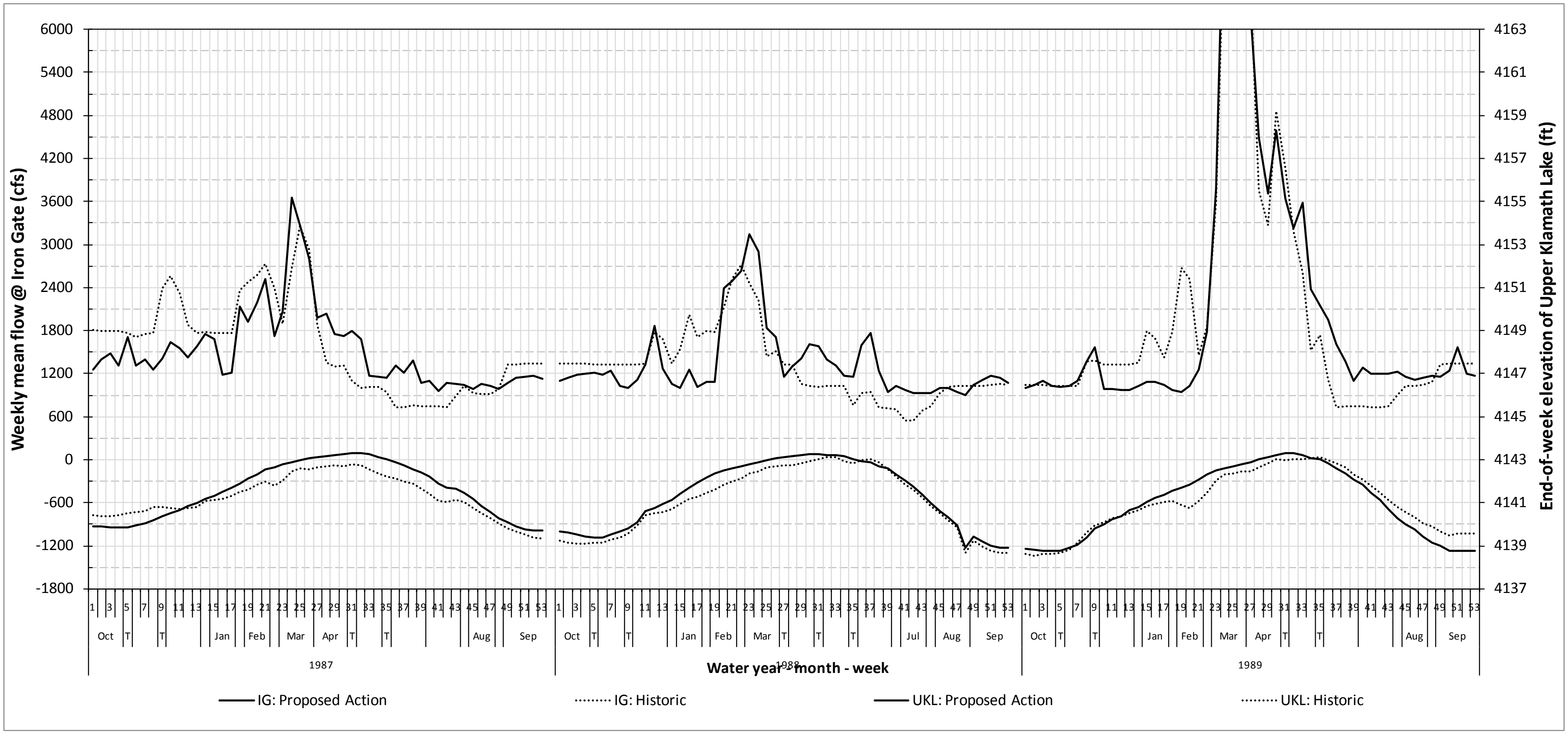


Figure B3. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (1987-1989)

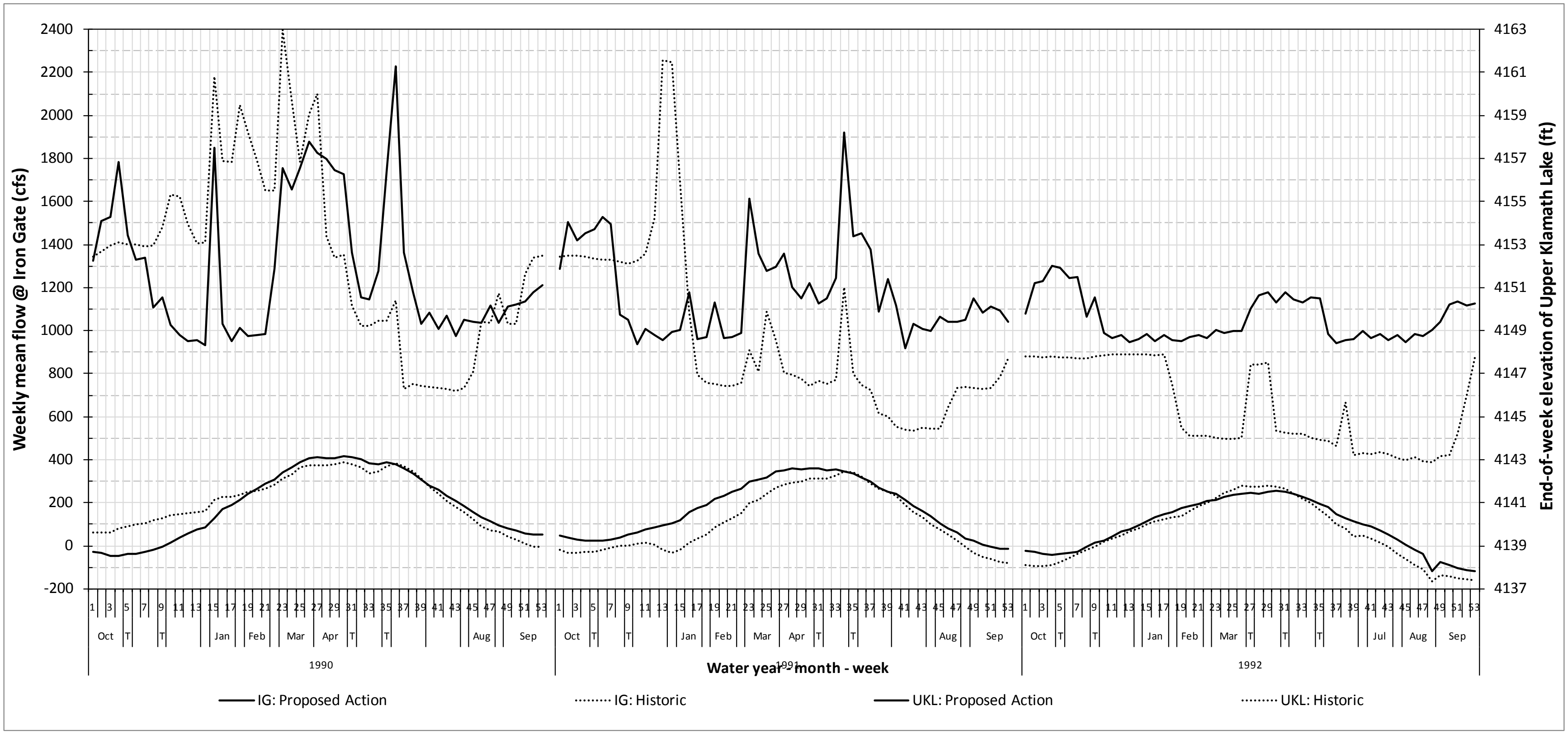


Figure B4. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (1990-1992)

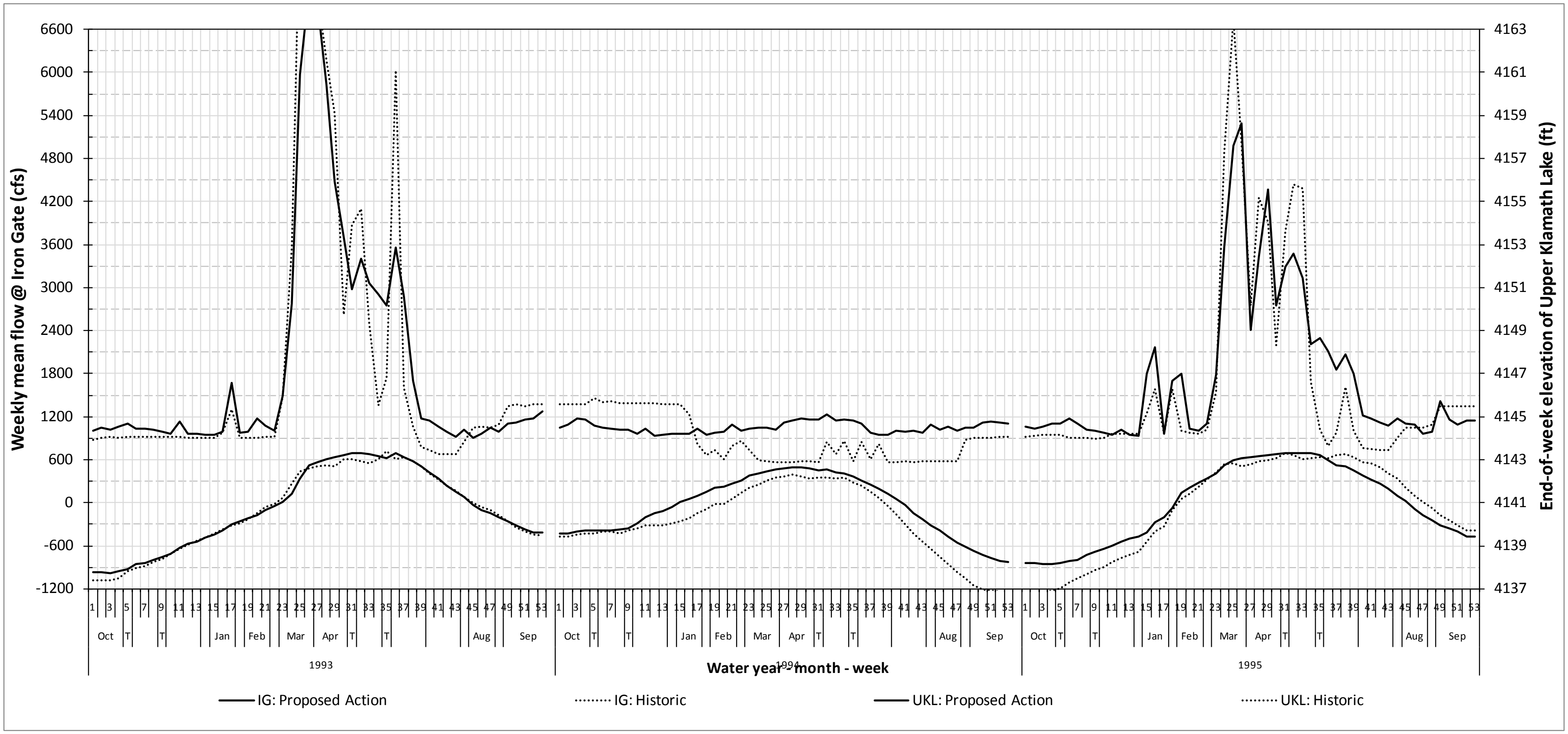


Figure B5. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (1993-1995)

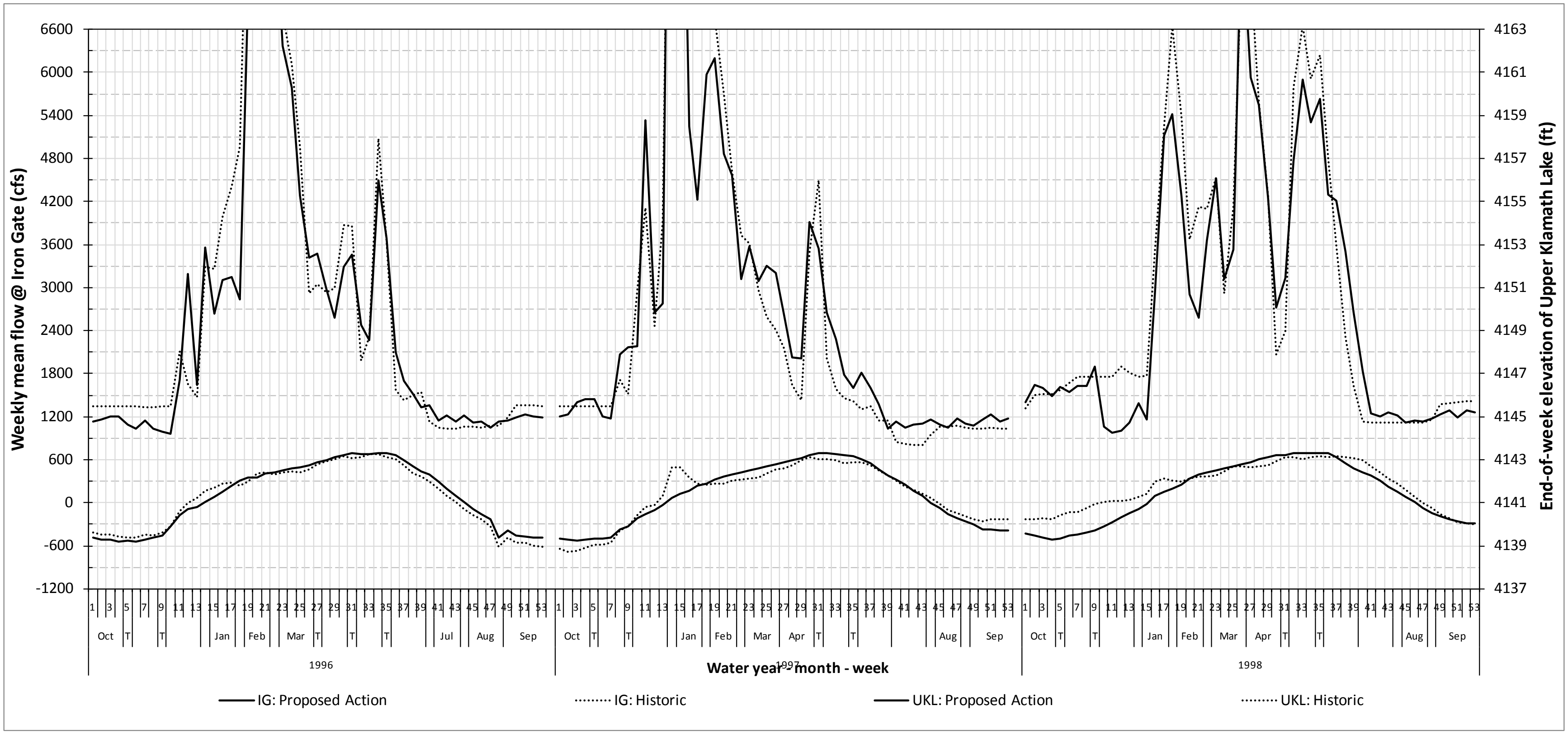


Figure B6. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (1996-1998)

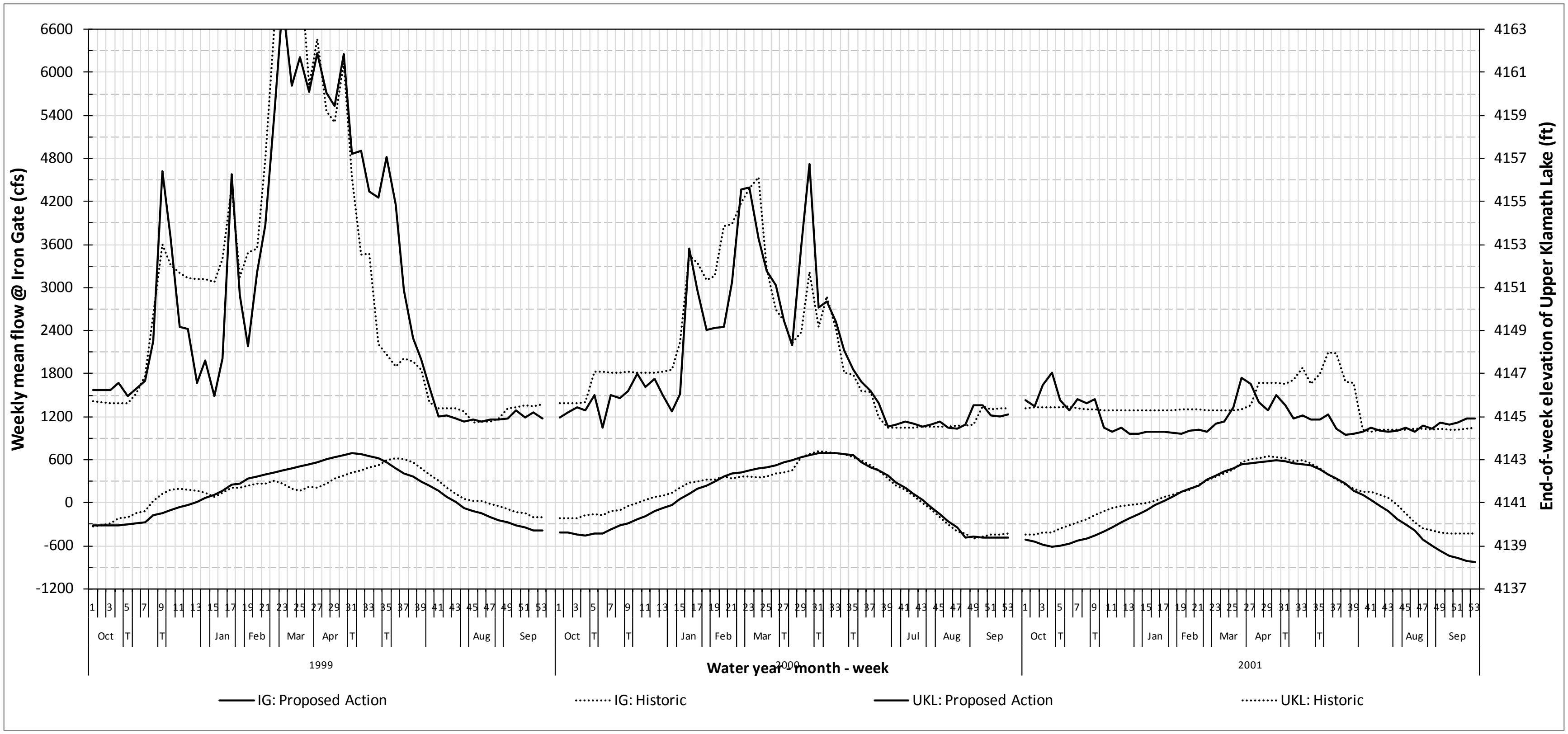


Figure B7. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (1999-2001)

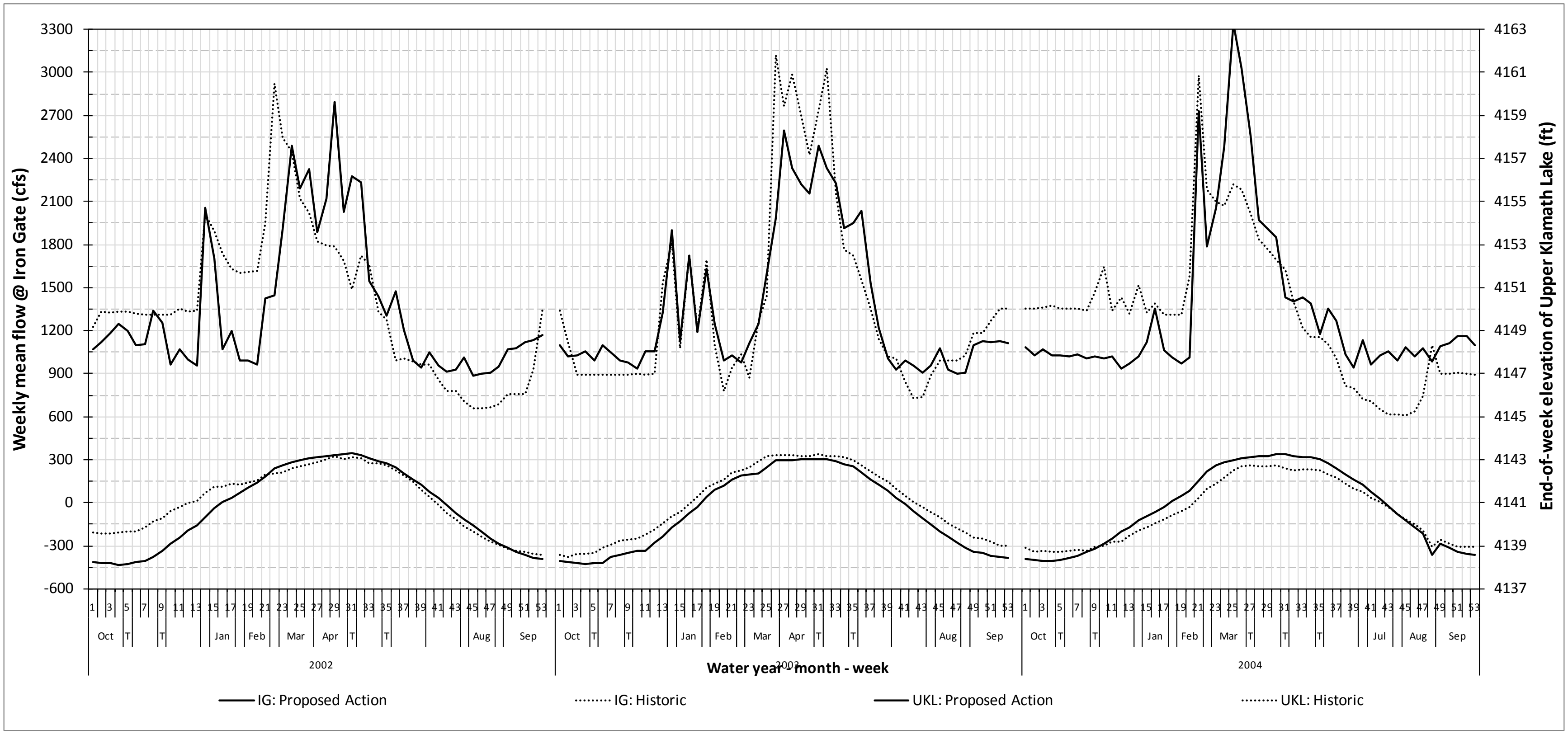


Figure B8. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (2002-2004)

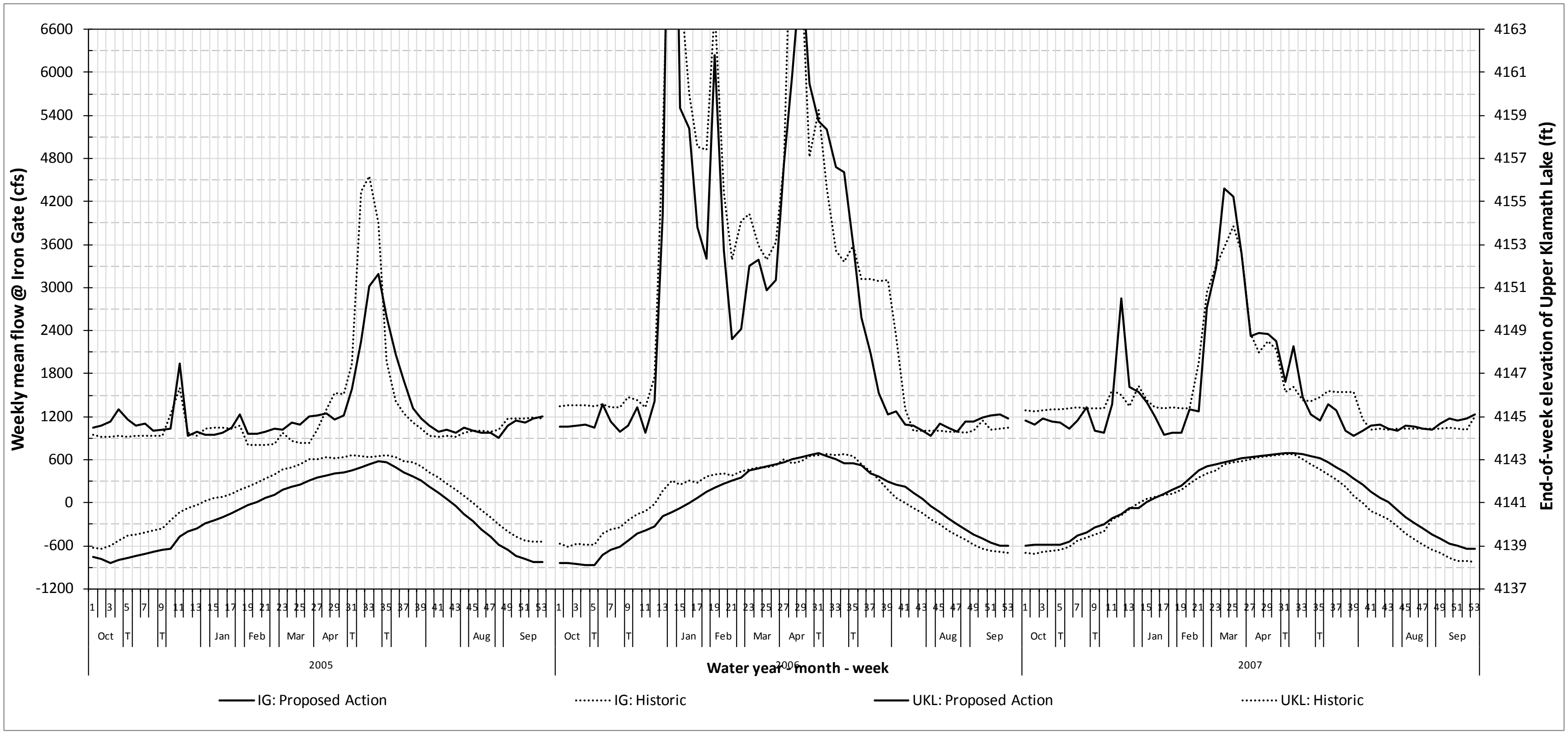


Figure B9. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (2005-2007)

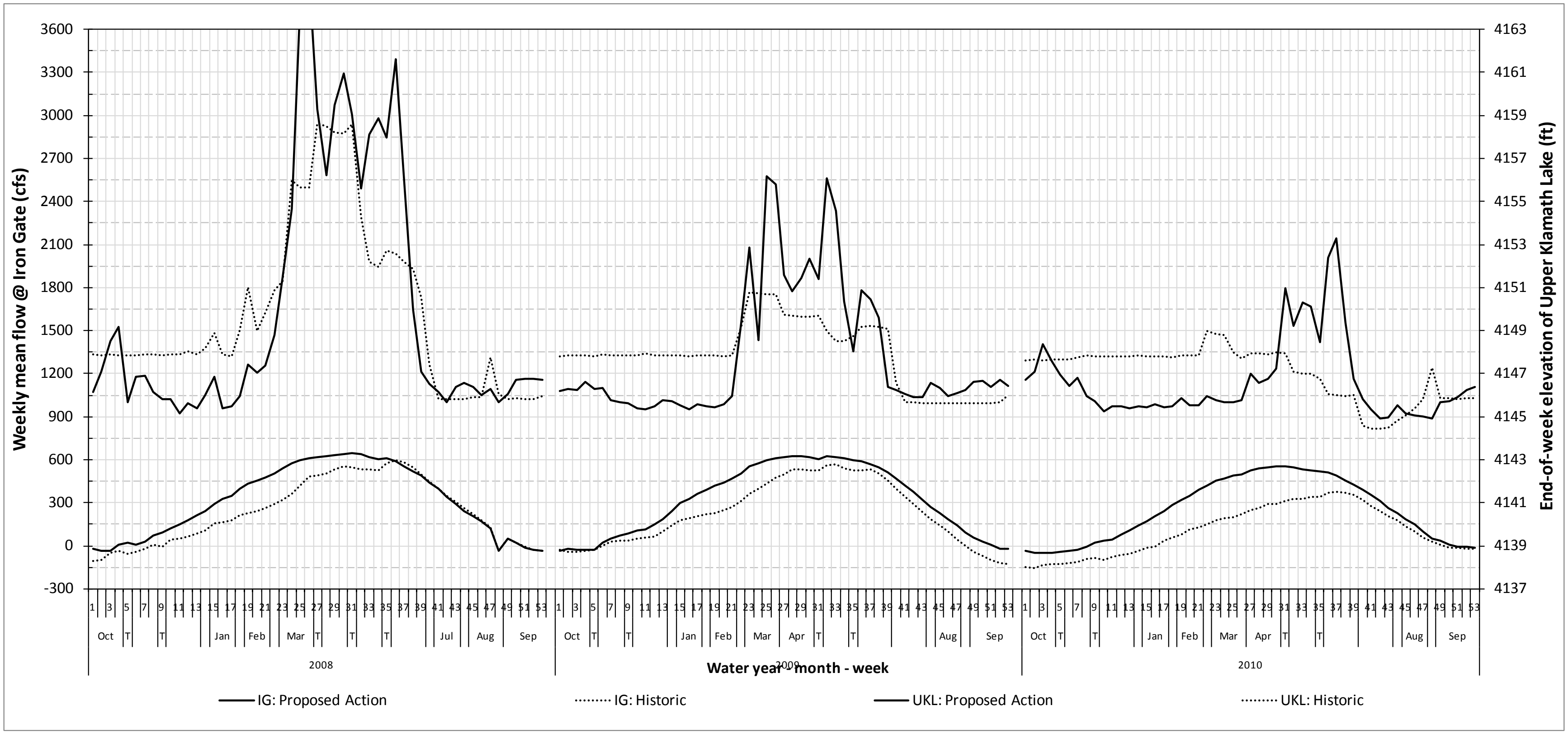


Figure B10. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (2008-2010)

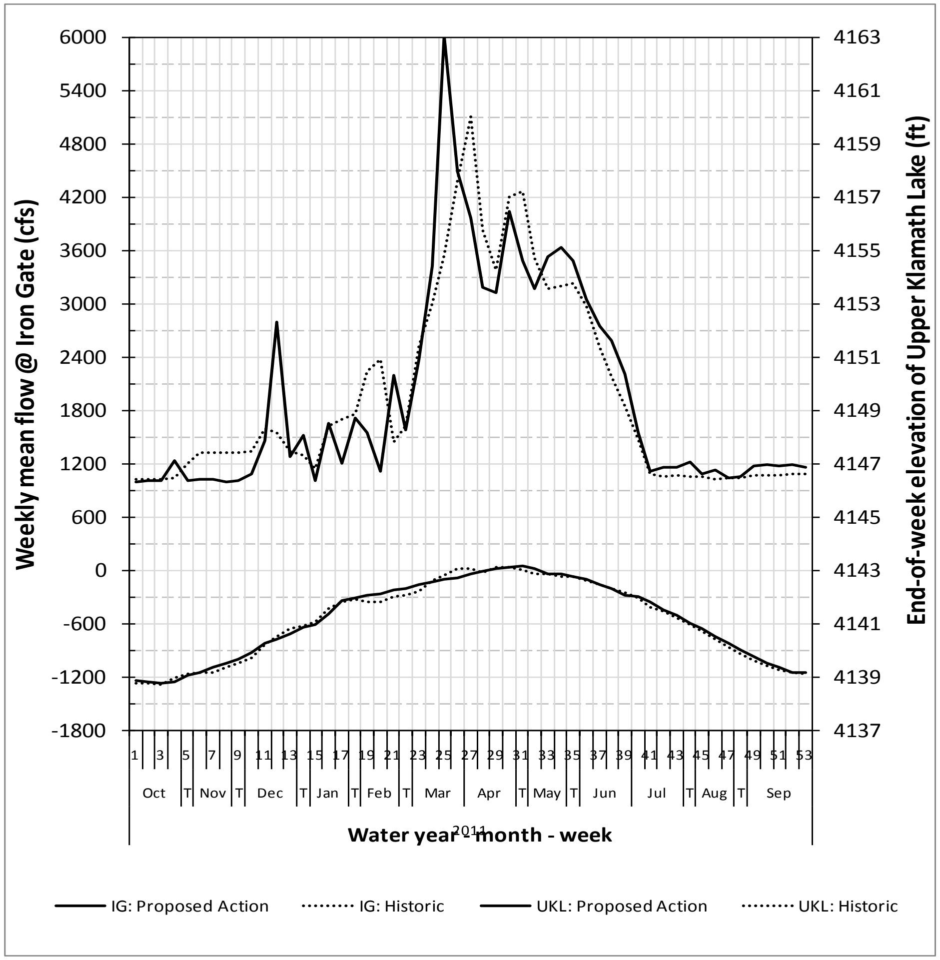


Figure B11. Modeled versus Historic Iron Gate Flows and Upper Klamath Lake Elevations (2011)

Figures B12-B22 below show the modeled deliveries versus those observed historically. The modeling results are intended to help assess how historical irrigation deliveries compare to those expected under this Proposed Action.

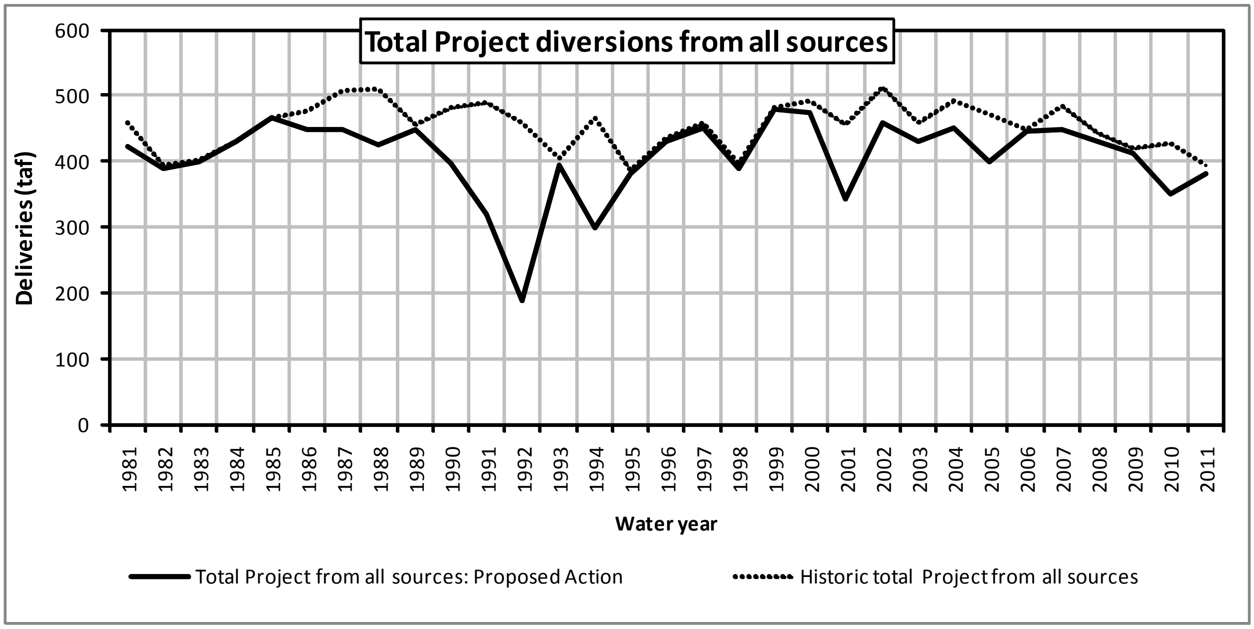


Figure B12. Modeled Annual Diversions versus Historic Diversions from All Sources

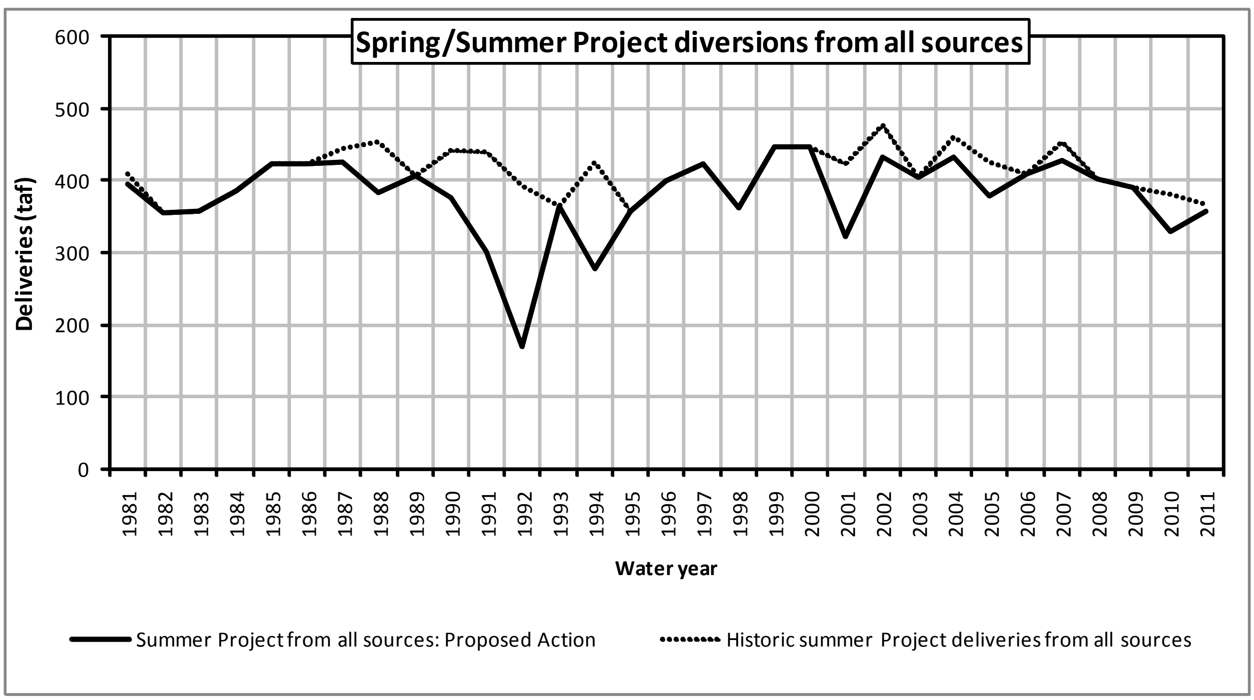


Figure B13. Modeled Spring/Summer (Mar-Nov) Deliveries versus Historic Deliveries from All Sources

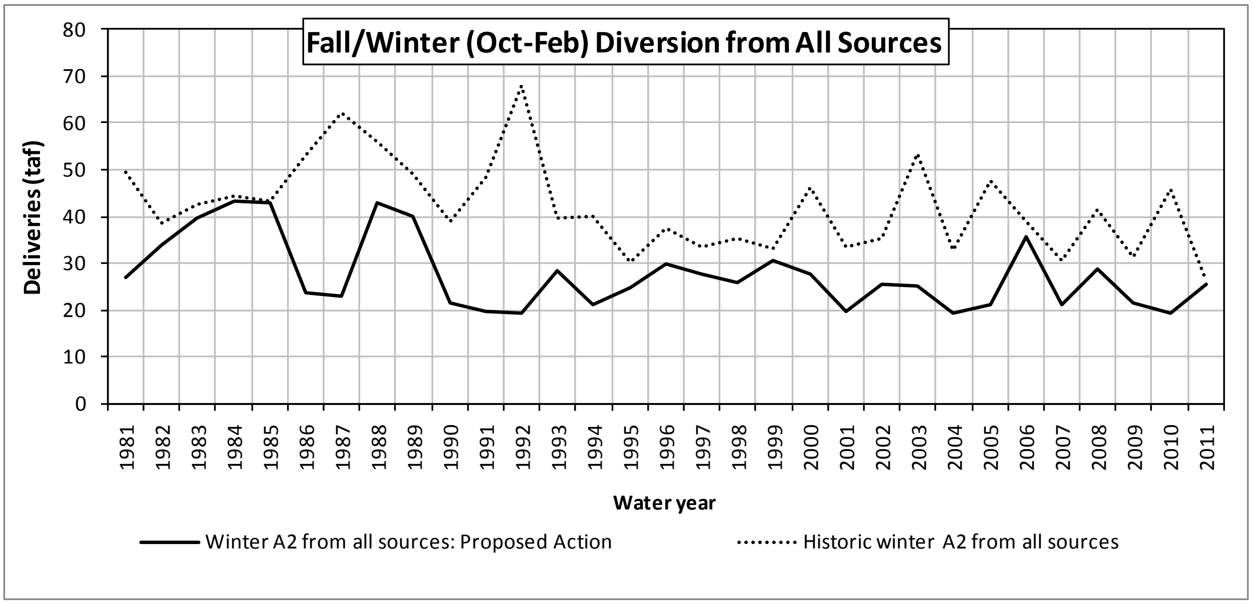


Figure B14. Modeled Fall/Winter Deliveries versus Historic Deliveries from All Sources

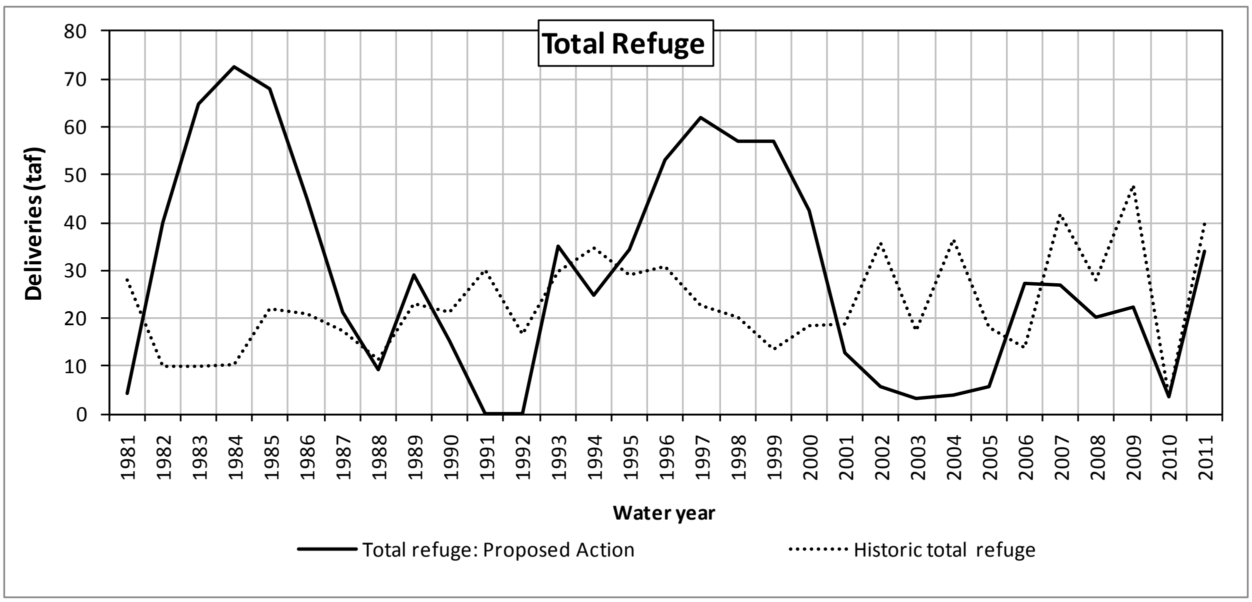


Figure B15. Modeled Annual Deliveries versus Historic Deliveries to Refuge

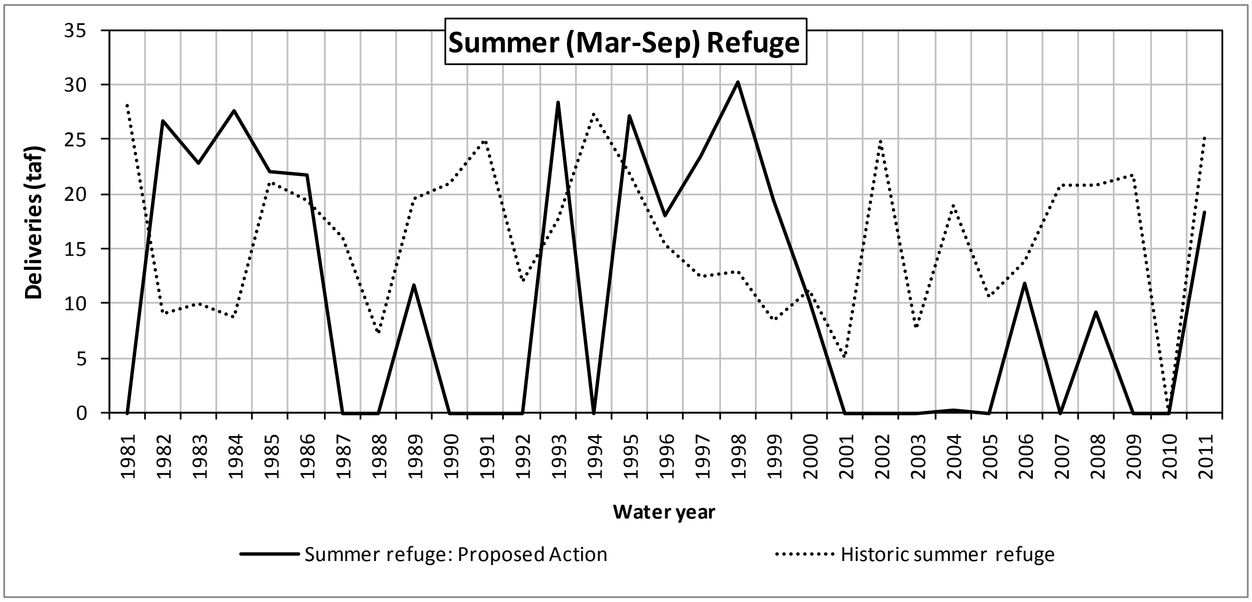
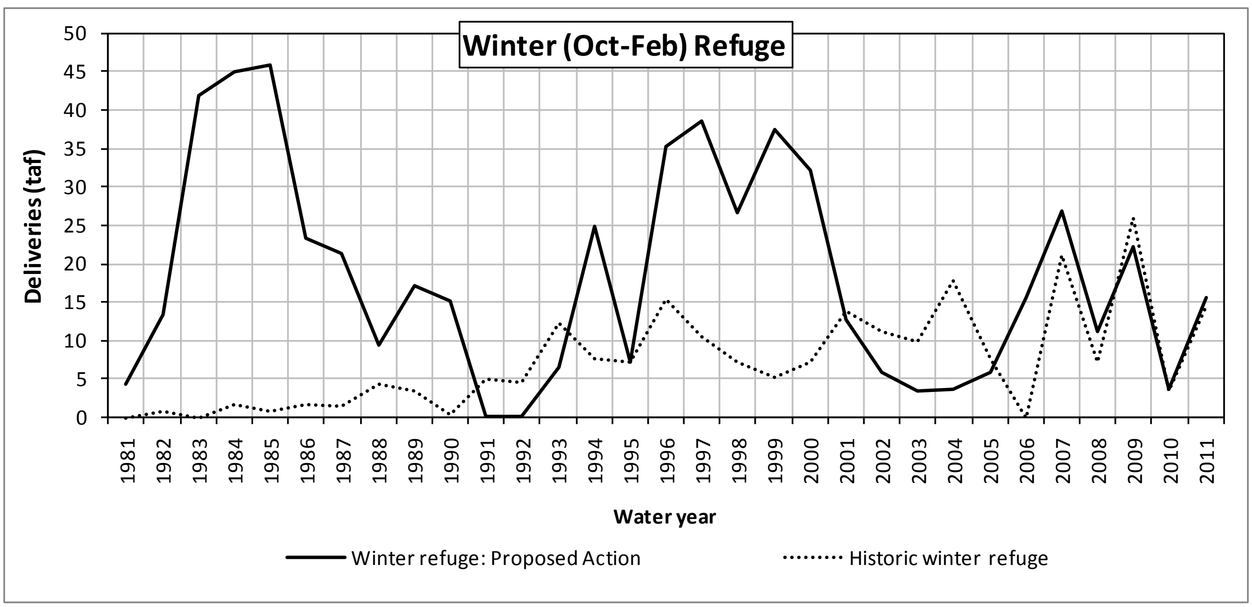


Figure B16. Modeled Summer Deliveries versus Historic Deliveries to Refuge



B17. Modeled Winter Deliveries versus Historic Deliveries to Refuge

Section C: Lower Klamath NWR Historic Deliveries

Table C1. Historic Lower Klamath NWR Water Deliveries

Water Year	Ady Canal Deliveries to LKNWR	D Plant Deliveries to LKNWR	Total Deliveries to LKNWR
1981	29.8	51.6	81.4
1982	10.7	108.4	119.1
1983	10.0	97.7	107.7
1984	2.1	102.9	105.0
1985	23.0	86.2	109.2
1986	20.5	88.8	109.2
1987	18.6	84.3	102.9
1988	11.7	78.8	90.5
1989	24.0	84.7	108.7
1990	23.4	80.6	104.0
1991	32.6	55.7	88.3
1992	14.8	36.7	51.5
1993	33.2	82.1	115.3
1994	38.8	42.6	81.4
1995	27.9	76.7	104.6
1996	29.4	103.0	132.4
1997	23.9	77.1	101.0
1998	20.5	85.6	106.1
1999	16.3	100.6	116.9
2000	22.4	68.5	90.9
2001	20.5	21.9	42.5
2002	39.8	75.2	115.0
2003	21.1	59.1	80.2
2004	46.3	50.4	96.7
2005	29.5	64.3	93.8
2006	24.3	109.4	133.7
2007	43.0	28.5	71.5
2008	27.6	51.1	78.7
2009	48.7	30.6	79.3
2010	6.8	8.1	14.9
2011	46.1	19.4	65.5
Average 1981-2011	25.40	68.08	93.48

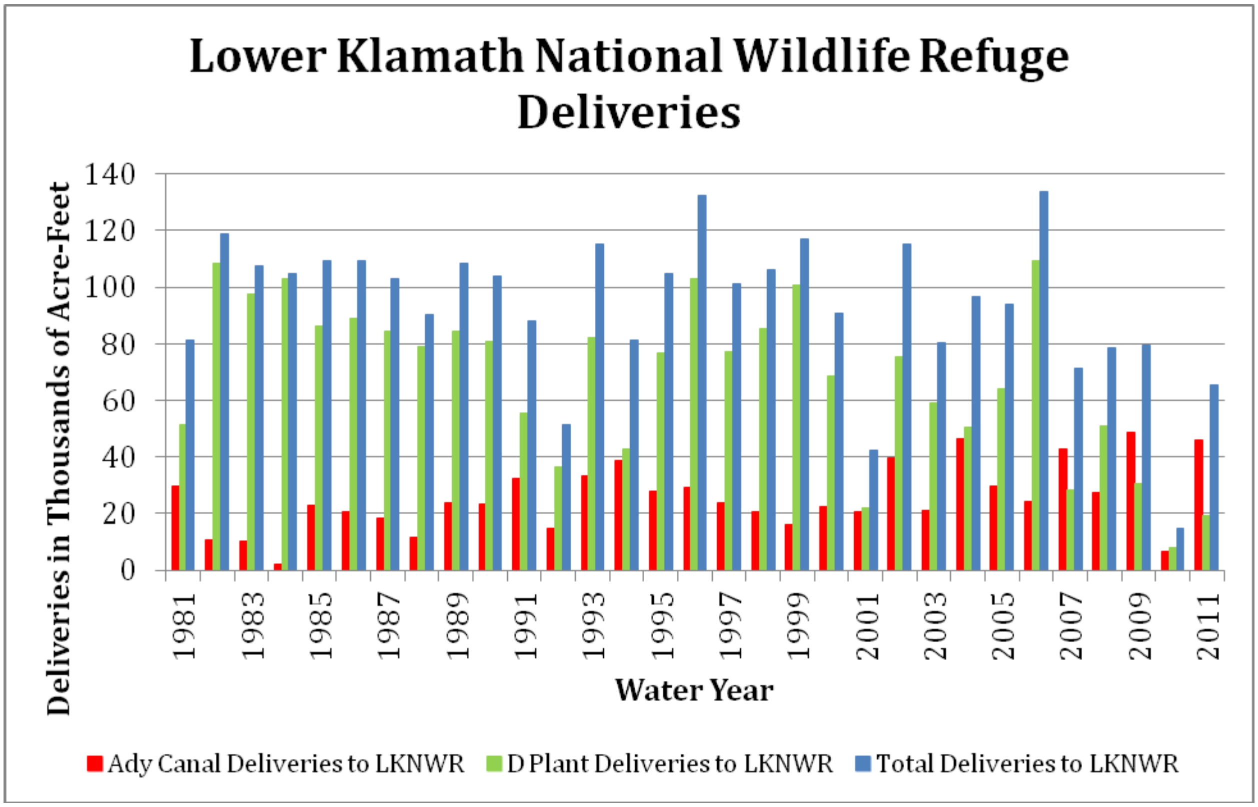


Figure C1. Historic Lower Klamath NWR Water Deliveries

Section D: Clear Lake and Gerber Water Supply Forecast Models

Table D1. Clear Lake Operational Forecast Model (April 1 – 50% Exceedance)

Time Period	Forecasted Inflow (50% exceedance), Acre-Feet	Irrigation Releases, Acre-Feet	Losses					Total Outflow, Acre-Feet	Storage, Acre-Feet	Elevation, Feet
			Submerged/ Surface Area, Acres	Seepage, Feet per Acre	Total Seepage, Acre-Feet	Evap, Feet per Acre	Total Evap, Acre-Feet			
									155,010	4,527.50
Apr 1-15	10,738	115	19,980	0.05	999	0.18	3,497	4,610	161,138	4,527.80
Apr 16-30	10,738	115	20,150	0.05	1,008	0.18	3,526	4,648	167,229	4,528.10
May 1-15	3,360	2,746	20,300	0.05	1,015	0.21	4,263	8,024	162,565	4,527.87
May 16-31	3,360	2,746	20,150	0.05	1,008	0.21	4,232	7,985	157,940	4,527.64
Jun 1-15	1,442	3,570	20,050	0.05	1,003	0.26	5,113	9,685	149,697	4,527.23
Jun 16-30	1,442	3,570	19,790	0.05	990	0.26	5,046	9,605	141,534	4,526.81
Jul 1-31	721	7,818	19,540	0.05	977	0.72	14,069	22,864	119,391	4,525.65
Aug 1-31	464	7,656	18,730	0.05	937	0.64	11,987	20,580	99,275	4,524.55
Sep 1-30	775	5,662	17,660	0.05	883	0.47	8,300	14,845	85,205	4,523.73

Clear Lake Biological Opinion Minimum Elevation	4,520.60	Feet
Resulting Biological Opinion Minimum Storage	41,150	Acre-Feet
Forecasted Water Available for Delivery	78,075	Acre-Feet

Clear Lake Operational Minimum Elevation	4,522.00	Feet
Resulting Operational Minimum Storage	58,280	Acre-Feet
Forecasted Water Available for Delivery	60,945	Acre-Feet

Table D2. Clear Lake Operational Forecast Model (April 1 – 70% Exceedance)

Time Period	Forecasted Inflow (70% exceedance), Acre-Feet	Irrigation Releases, Acre-Feet	Losses					Total Outflow, Acre-Feet	Storage, Acre-Feet	Elevation, Feet
			Submerged/ Surface Area, Acres	Seepage, Feet per Acre	Total Seepage, Acre-Feet	Evap, Feet per Acre	Total Evap, Acre-Feet			
									155,010	4,527.50
Apr 1-15	7,364	115	19,980	0.05	999	0.18	3,497	4,610	157,764	4,527.63
Apr 16-30	7,364	115	20,050	0.05	1,003	0.18	3,509	4,626	160,501	4,527.77
May 1-15	2,304	2,746	20,100	0.05	1,005	0.21	4,221	7,972	154,834	4,527.49
May 16-31	2,304	2,746	19,920	0.05	996	0.21	4,183	7,925	149,213	4,527.20
Jun 1-15	989	3,570	19,790	0.05	990	0.26	5,046	9,605	140,596	4,526.76
Jun 16-30	989	3,570	19,480	0.05	974	0.26	4,967	9,511	132,074	4,526.32
Jul 1-31	989	7,818	19,240	0.05	962	0.72	13,853	22,633	110,430	4,525.17
Aug 1-31	636	7,656	18,280	0.05	914	0.64	11,699	20,269	90,797	4,524.06
Sep 1-30	1,063	5,662	17,110	0.05	856	0.47	8,042	14,559	77,301	4,523.24

Clear Lake Biological Opinion Minimum Elevation	4,520.60	Feet
Resulting Biological Opinion Minimum Storage	41,150	Acre-Feet
Forecasted Water Available for Delivery	70,171	Acre-Feet

Clear Lake Operational Minimum Elevation	4,522.00	Feet
Resulting Operational Minimum Storage	58,280	Acre-Feet
Forecasted Water Available for Delivery	53,041	Acre-Feet

Table D3. Clear Lake Operational Forecast Model (April 1 – 90% Exceedance)

Time Period	Forecasted Inflow (90% exceedance), Acre-Feet	Irrigation Releases, Acre-Feet	Losses						Total Outflow, Acre-Feet	Storage, Acre-Feet	Elevation, Feet
			Submerged/ Surface Area, Acres	Seepage, Feet per Acre	Total Seepage, Acre-Feet	Evap, Feet per Acre	Total Evap, Acre-Feet				
										155,010	4,527.50
Apr 1-15	2,761	115	19,980	0.05	999	0.18	3,497		4,610	153,161	4,527.40
Apr 16-30	2,761	115	19,920	0.05	996	0.18	3,486		4,597	151,326	4,527.31
May 1-15	864	2,746	19,850	0.05	993	0.21	4,169		7,907	144,284	4,526.95
May 16-31	864	2,746	19,600	0.05	980	0.21	4,116		7,842	137,306	4,526.60
Jun 1-15	371	3,570	19,420	0.05	971	0.26	4,952		9,493	128,184	4,526.12
Jun 16-30	371	3,570	19,120	0.05	956	0.26	4,876		9,401	119,154	4,525.64
Jul 1-31	371	7,818	18,730	0.05	937	0.72	13,486		22,240	97,285	4,524.43
Aug 1-31	238	7,656	17,550	0.05	878	0.64	11,232		19,766	77,758	4,523.27
Sep 1-30	399	5,662	16,090	0.05	805	0.47	7,562		14,029	64,127	4,522.39

Clear Lake Biological Opinion Minimum Elevation	4,520.60	Feet
Resulting Biological Opinion Minimum Storage	41,150	Acre-Feet
Forecasted Water Available for Delivery	56,997	Acre-Feet
Clear Lake Operational Minimum Elevation	4,522.00	Feet
Resulting Operational Minimum Storage	58,280	Acre-Feet
Forecasted Water Available for Delivery	39,867	Acre-Feet

Table D4. Gerber Reservoir Operational Forecast Model (April 1 – 50% Exceedance)

Time Period	Forecasted Inflow (50% exceedance), Acre-Feet	Irrigation Releases, Acre-Feet	Losses			Total Outflow, Acre-Feet	Storage, Acre-Feet	Elevation, Feet
			Submerged/ Surface Area, Acres	Evap and Seepage, Feet per Acre	Total Evap and Seepage, Acre-Feet			
							56,916	4,824.79
Apr 1-15	4,201	106	2,790	0.12	321	426	60,690	4,825.95
Apr 16-30	4,201	106	2,898	0.12	333	439	64,452	4,827.09
May 1-15	1,158	2,736	3,003	0.15	435	3,171	62,440	4,826.48
May 16-31	1,158	2,736	2,947	0.15	427	3,163	60,436	4,825.87
Jun 1-15	352	3,403	2,891	0.20	564	3,967	56,821	4,824.75
Jun 16-30	352	3,403	2,788	0.20	544	3,947	53,227	4,823.60
Jul 1-31	285	7,996	2,681	0.55	1,475	9,471	44,042	4,820.58
Aug 1-31	140	7,675	2,403	0.48	1,153	8,828	35,353	4,817.53
Sep 1-30	152	6,235	2,122	0.33	700	6,935	28,569	4,814.94

Gerber Biological Opinion Minimum Elevation	4,798.10	Feet
Resulting Biological Opinion Minimum Storage	1,308	Acre-Feet
Forecasted Water Available for Delivery	62,272	Acre-Feet

Table D5. Gerber Reservoir Operational Forecast Model (April 1 – 70% Exceedance)

Time Period	Forecasted Inflow (70% exceedance), Acre-Feet	Irrigation Releases, Acre-Feet	Losses			Total Outflow, Acre-Feet	Storage, Acre-Feet	Elevation, Feet
			Submerged/ Surface Area, Acres	Evap and Seepage, Feet per Acre	Total Evap and Seepage, Acre-Feet			
							56,916	4,824.79
Apr 1-15	2,520	106	2,790	0.12	321	426	59,010	4,825.43
Apr 16-30	2,520	106	2,850	0.12	328	433	61,097	4,826.07
May 1-15	695	2,736	2,909	0.15	422	3,157	58,635	4,825.31
May 16-31	695	2,736	2,839	0.15	412	3,147	56,183	4,824.54
Jun 1-15	211	3,403	2,768	0.20	540	3,943	52,452	4,823.36
Jun 16-30	211	3,403	2,659	0.20	519	3,922	48,742	4,822.15
Jul 1-31	171	7,996	2,548	0.55	1,401	9,397	39,515	4,818.87
Aug 1-31	84	7,675	2,245	0.48	1,078	8,753	30,847	4,815.84
Sep 1-30	91	6,235	1,966	0.33	649	6,884	24,054	4,813.08

Gerber Biological Opinion Minimum Elevation	4,798.10	Feet
Resulting Biological Opinion Minimum Storage	1,308	Acre-Feet
Forecasted Water Available for Delivery	57,757	Acre-Feet

Table D6. Gerber Reservoir Operational Forecast Model (April 1 – 90% Exceedance)

Time Period	Forecasted Inflow (90% exceedance), Acre-Feet	Irrigation Releases, Acre-Feet	Losses			Total Outflow, Acre-Feet	Storage, Acre-Feet	Elevation, Feet
			Submerged/ Surface Area, Acres	Evap and Seepage, Feet per Acre	Total Evap and Seepage, Acre-Feet			
							56,916	4,824.79
Apr 1-15	249	106	2,790	0.12	321	426	56,738	4,824.72
Apr 16-30	249	106	2,785	0.12	320	426	56,561	4,824.66
May 1-15	69	2,736	2,779	0.15	403	3,138	53,491	4,823.69
May 16-31	69	2,736	2,690	0.15	390	3,126	50,434	4,822.70
Jun 1-15	21	3,403	2,599	0.20	507	3,910	46,545	4,821.42
Jun 16-30	21	3,403	2,480	0.20	484	3,887	42,679	4,820.11
Jul 1-31	17	7,996	2,360	0.55	1,298	9,294	33,402	4,816.80
Aug 1-31	8	7,675	2,055	0.48	986	8,661	24,749	4,813.38
Sep 1-30	9	6,235	1,739	0.33	574	6,809	17,949	4,810.34

Gerber Biological Opinion Minimum Elevation	4,798.10	Feet
Resulting Biological Opinion Minimum Storage	1,308	Acre-Feet
Forecasted Water Available for Delivery	51,652	Acre-Feet

Appendix 4B: Example: Plan to Relocate Tule Lake Suckers

Example: Tule Lake (Siskiyou County) California Adult Sucker Relocation

Background

Currently, Tule Lake in northern Siskiyou County, California, is the remnant of a larger lake by the same name. Tule Lake (both Sumps 1A and 1B), Tule Lake National Wildlife Refuge and surrounding private agricultural lands occupy the historic lake bed of the original Tule Lake (approximately 95,000 acres) in both California and Oregon. Presently Tule Lake consists of approximately 10,500 acres of shallow open water (Sump 1A, 6,500 acres, 0.25-4.0 ft depth; Sump 1B, 3,500 acres, 2.0-4.0 ft depth). Studies indicate that adult suckers primarily reside in Sump 1A of Tule Lake during spring, summer and fall months (Hicks et al. 1999, Beckstrand et al. 2000). Both Klamath Basin ESA-listed sucker species (Lost River suckers, *Deltistes luxatus*; shortnose suckers, *Chasmistes brevirostris*) currently inhabit Tule Lake and may number in the several hundreds to thousands (Scoppettone et al. 1995, Hodge 2007, 2008, Hodge and Buettner 2009).

Historically Tule Lake was fed by flow from the Lost River and overflow from the upper Klamath River; however, Clear Lake was dammed early in the 20th Century to reduce flows in the Lost River, and any substantial accretions in the Lost River are now diverted to the Klamath River, and the only water flowing to Tule Lake from the Klamath River now is for agriculture. As a result, inflows to Tule Lake are primarily the result of agricultural returns from groundwater and surface water from Upper Klamath Lake. Because of low reservoir levels and substantially-reduced deliveries to agriculture as a result of drought, Reclamation is likely unable to maintain a minimum elevation of 4034.6 ft. Because evaporative losses from Tule Lake are likely to exceed 3 feet through the summer, maximum water depths are anticipated to be no more than 1-2 feet by the end of summer. Concerns are that with these shallow depths, suckers will be highly vulnerable to white pelican predation, poor water quality, and masses of filamentous algae. Given the likelihood of Tule Lake surface elevation dropping to a level that may compromise sucker health and survival, an effort to salvage adult suckers from Tule Lake is planned in the spring of 2010 prior to water temperature becoming too high (greater than 15º C) or the lake elevation becoming too low. Salvaged adult suckers will be handled and transported consistent with Sucker Handling Guidelines for Klamath Basin Suckers (Reclamation, October 2008; Appendix 1).

Potential relocation sites for the salvaged suckers include Upper Klamath Lake, Clear Lake, and Gerber Reservoir. Clear Lake has several advantages because it is in the same watershed as Tule Lake and is in California, which makes permitting easier. The primary disadvantages to Clear Lake Reservoir are its distance over remote, poorly maintained roads and it is a shallow lake that may also be influenced by drought conditions. Gerber Reservoir is within the same watershed as Tule Lake on the Oregon side which makes permitting a potential problem (i.e., transport of fish across state lines). A possible advantage of moving some Lost River suckers to Gerber is that if a new self-sustaining population could be established it may benefit recovery. However, Gerber is relatively small and lake levels there are also influenced by drought conditions. Upper Klamath Lake is perhaps the best relocation option for the fish. Although Upper Klamath Lake is relatively low this year, it has the most habitat of any of the upper basin lakes with sucker populations. Disadvantages of Upper Klamath Lake are that it is both in a different state, making permitting more complex, and it is in a different subbasin. Although Tule Lake and Upper

Klamath Lake are in different subbasins, most of the water reaching Tule Lake is from Upper Klamath Lake that passes through the Klamath Project canals. Previous discussions with the Oregon Department of Fish and Wildlife indicate that under extreme circumstances they will consider out of basin and across state line transfers of endangered suckers.

Anticipated Tule Lake depths are 1 to 1.5 m during relocation efforts in March through June. The shallowest area of water likely to be encountered is within 100 m of the Tule Lake boat launch off Hill Road. Shallow draft boats (e.g., jon or utility boats, etc) with propeller motors are sufficient at lake elevations expected during these months.

Objective

To relocate adult suckers from Tule Lake to a more stable environment within the historic range of Klamath Basin sucker species (i.e., Upper Klamath Lake, Oregon, or Clear Lake, California) prior to a surface elevation drop in Tule Lake that may compromise sucker survival. By-catch species will be released into Tule Lake upon capture.

Methods

To be consistent with Reclamation's permits or Biological Opinion for ESA-listed suckers. The following method is recommended, but other methods in conjunction with the primary method below will be equally considered.

Many standard fish sampling gear can be employed to effectively capture adult suckers. The preferred method is using 300 ft length trammel nets with 1.5 inch bar mesh on the inside (primary) panel and 12 inch mesh on both of the outside panels. This method has proven safe and effective for capture of adult suckers during other fish studies in the Upper Klamath Basin. Trammel nets will be inspected for entangled fish approximately once an hour. Non-target fish species will be released at the point of capture. Captured adult suckers will be removed from nets and held in aerated live-wells aboard the capture boat while net inspections are conducted and before transfer to land-based transport. Ferrying captured suckers to land-based transport should occur between inspections of nets to ensure that fish are held no longer than necessary. Other methods, such as long-handled dipnets, seines or electro-fishing, may be considered and employed if there is indication the method may be effective to capture adult suckers (e.g., concentrated fish in a small area).

Ideally adult sucker capture, handling and transport will occur before water temperatures in Tule Lake reach 15 ºC. While water temperatures are below 15º C, each captured fish should be identified to species and sex, measured for fork length (mm), and implanted near the pelvic girdle with a passive integrated transponder (PIT) tag via a large gauge needle and plunger. Species, sex, length and PIT tag serial will be recorded for adult suckers. When water temperatures are between 15 and 20º C, fish salvage will continue but handling times will be reduced through the elimination of identifying sex, measuring length, and PIT tagging. Thus, water temperature in Tule Lake is an important aspect of this plan and will be monitored closely. Captured adult suckers will be held in aerated live-wells while aboard the capture boat. Fish will be routinely transported from the netting locations on Tule Lake to land-based transport approximately every hour. Fish will be transferred from boat live-wells to larger aerated live-wells (approximately 200 gallon) for land-based transport. Large live-wells are constructed to fit in the open bed of a standard pickup truck or on a trailer and will be filled to 80% capacity (about 160 gallons) of well water or domestic water that has been treated to remove chlorination. Fish will be transported in these large live-wells to approved release sites on Upper Klamath Lake (or Clear Lake) in a manner consistent with Sucker Handling Guidelines for Klamath Basin Suckers (Reclamation October 2008; Appendix 1). Temperature and dissolved oxygen should be monitored during transport. Water temperature in live-wells may need tempering with ice when temperatures exceed 15-16º C.

Transport crews may consist of one or two crewmembers to transfer fish between live-wells, maintain aeration equipment, monitor water temperature, stocking densities and dissolved oxygen in live-wells, and driving vehicles to release sites. Release of captured fish, dependent upon the live-well used, can either occur as release of water and fish from the live-well down a rigid slide into release waters or as a transfer of fish from the live-well to release waters using a dipnet. If water and fish are simultaneously released, then drivers will replenish the transport live-wells with water (well or treated domestic supply) before returning to the Tule Lake boat launch area. Two or three transport crews will work in unison with two or three capture crews during the primary adult sucker salvage effort so that transportation of fish is a continuous process.

All fish will be released at sites with more permanent water. Upper Klamath Lake is likely the primary release site. Final release sites will be decided upon through conferencing with Oregon Department of Fish and Wildlife, California Department of Fish and Game, the Klamath Tribes, and U.S. Fish and Wildlife Service. Boat ramp release sites on Upper Klamath Lake and Clear Lake should be considered within the proposal. Potential (but not all) release sites include:

A. Moore Park in Klamath Falls – 32 miles, 50 minutes

B. Howard Bay off Highway 140 – 38 miles, 50 minutes

C. Hagelstein County Park off Highway 97 – 40 miles, 60 minutes

D. Shoalwater Bay (Eagle Ridge County Park) –50 miles, 75 minutes

E. Modoc Point unimproved boat launch – 44 miles, 60 minutes

F. Williamson River Delta Nature Conservancy boat launch – 53 miles, 75 minutes

G. Pelican Bay, 60 miles, 80 minutes

H. Odessa Creek unimproved boat launch, 51 miles, 75 minutes

I. Harriman Springs (near Pelican Bay), 60 miles, 80 minutes

J. The only stable-environment, release site in California within the historic range of both Lost River and shortnose suckers are unimproved boat launches on the west lobe and east lobe of Clear Lake Reservoir via forest service roads off Highway 39/139 about 35 miles and 120 minutes from Tule Lake Sump 1A.

Equipment Needs

-Minimum of two capture crews (two-person crew working from shallow draft boats), and two land-based transportation crews (one- or two-person crew transporting suckers from Tule Lake to a release site).
-Two land-based transportation vehicles suitable for water tanks.
-Two watercraft suitable for shallow water operation.
-Fish handling equipment to include fish measuring boards, temporary floating net pens, dip nets, electrofishers, trammel nets, seines, PIT tagging equipment and tags.

Deliverables

A summary report will include a measure of effort and captured fish. The summary report should include water temperatures (i.e., natural bodies of water and transport live-wells) during transport and the additional data gathered from adult suckers while water temperatures permit the data collection (i.e., fork lengths, species, sex, and PIT tag serials on individual adult suckers). A draft summary report is anticipated within 60 days of concluding fish relocation effort.

Literature Cited

Beckstrand, J., D.M. Mauser, D. Thomson, and L.A. Hicks. 2000. Ecology of shortnose and Lost River suckers in Tule Lake National Wildlife Refuge, California, Progress report #2, February – December, 2000. 55p.

Hicks, L.A., D.M. Mauser, J. Beckstrand, and D. Thomson. 1999. Ecology of shortnose and Lost River suckers in Tule Lake National Wildlife Refuge, California, Progress Report, April – November 1999. 39p.

Hodge, J. 2007. 2006 sucker spawning in the lower Lost River, Oregon. Unpublished report. U.S. Fish and Wildlife Service, Klamath Falls Fish and Wildlife Office, Oregon. March 23, 2007. 18 p.

Hodge, J. 2008. Sucker population monitoring in Tule Lake and Lower Lost River, Oregon and California. Unpublished report. U.S. Fish and Wildlife Service, Klamath Falls Fish and Wildlife Office, Oregon.

Hodge, J. and M. Buettner. 2009. Sucker population monitoring in Tule Lake and Lower Lost River, 2006-2008. Unpublished report. U.S. Fish and Wildlife Service, Klamath Falls Fish and Wildlife Office, Oregon.

Appendix I. Sucker Handling Guidelines for Klamath Basin Suckers

Handling Guidelines for Klamath Basin Suckers

Reclamation, Klamath Basin Area Office
October 2008

Background

Reclamation has annually salvaged fish from throughout the Klamath Project canals since 1991. A reduced canal salvage effort was implemented following approval by USFWS with the construction and operation of the fish screens at A Canal and Clear Lake Dam in 2003. Much of Reclamation's past fish salvage efforts in Project canals has been conducted using electrofishing techniques.

Reclamation staff will continue to salvage suckers from Project canals following the dewatering of canals each autumn. Reclamation has prepared a salvage plan for the period 2008-2010. Reclamation proposes in that salvage plan to handle both salvage and trap and haul fish in manner that may improve survivorship of these fish. While Reclamation staff is committed to understanding the impact of electrofishing on juvenile suckers, this document is intended as guidance on how fish are handled after capture. If there is reason to suspect electrofishing results in significant injuries to juvenile suckers, then Reclamation will explore other techniques to capture fish to be salvaged.

The high pathogen/parasite loads of juvenile suckers in 2006 and 2007 from the Link River and J Canal of the Lost River system suggest that sucker survival may be impaired even when captured from and returned to natural environments of the Klamath Basin (Banner 2006, Banner and Stocking 2006, Banner 2007). Although there is evidence that juvenile sucker health may be impaired, surviving larval (early juvenile) suckers held at the A Canal in late summer 2007 only experienced episodic parasite infections that were characterized as 'mild' (Foott et al. 2007). The authors did not observe signs of disease due to either bacteria or external parasites, but did note internal bacterial flora was consistent while external parasites did change in species composition throughout the study. In contrast, bacteria (e.g., *Flavobacteria columnare* and *Aeromonas hydrophila*) have been associated with adult sucker losses in Upper Klamath Lake (Perkins et al. 2000, Cipriano et al. 2007).

The principal objective of both salvage effort and trap and haul activity is to return fish to environments in a manner that may improve individual survival. To improve health of salvaged suckers, Reclamation proposes to hold and transport them in saline solution at the concentrations listed below. The purpose of the saline solution is to improve osmoregulation and respiration of transported fish while in-transit. Furthermore, the use of saline solution during transport may also combat some of the external parasites common on fishes from Upper Klamath Lake (Foott 2004, Foott et al. 2007). The saline solution will only be mixed with un-chlorinated well water. Aeration will be provided through pressurized atmospheric air. A commercially available slime coat will be added to each tank. These measures should improve fish respiration during transport.

Reclamation proposes the following guidelines for safe fish handling after capture during both salvage and trap and haul activities for the period of 2008 through 2010. Reclamation will work with Dr. Scott Foott of USFWS, California-Nevada Fish Health Center, to evaluate the short-term sucker survivorship following both salvage and trap and haul. Reclamation and Dr. Foott will also collaborate to explore other options intended to increase survivorship of relocated suckers. This work is separate from the fish handling guidelines presented here. Reclamation proposes that biologists from USFWS and Reclamation discuss and consider revisions to these guidelines annually although this document is intended to be in use from 2008 through 2010 without revision. Reclamation will use a disinfectant, such as Virkon Aquatic (Western Chemical, Inc.; www.wchemical.com), to prevent spread of aquatic species or disease.

Holding of Klamath Basin Suckers

Immediate upon capture, suckers will be held in easily transported totes that contain a 0.5% saline solution of well water. When possible, aeration will be provided to these totes via an airstone and pressurized atmospheric air. These fish will be transferred to larger transport tanks following measurement and the above procedures will able for large or small transport tanks.

As of October 2008, Reclamation does not propose to hold adult or juvenile suckers beyond a period that is considered necessary before transporting and releasing. The holding of suckers for a 5 day period is only to maximize the efficiency of transport and release of suckers. During the trap and haul efforts, Reclamation will collect juvenile suckers from the A Canal fish bypass and/or the Link River for transport and release in the northern portion of Upper Klamath Lake. We propose to transport juvenile suckers once at the end of each week during trap and haul efforts. More frequent trips may be necessary if the number of juvenile suckers captured surpasses our capabilities to hold fish at the Fish Evaluation Station (FES). Reclamation approximates our fish-holding facilities at 200 to 1,000 juvenile suckers, dependent upon size of the juveniles. As a general rule, juvenile suckers will be transported for release when we have 100 individuals in holding and every Friday regardless of the number of fish. Fish will be held by Reclamation at the FES in a flow-through system with water from Upper Klamath Lake. If poor water quality conditions at the FES pose an immediate risk to sucker survival, then suckers will be transported and released without holding at this facility.

Held fish may be given a therapeutic saline bath once during captivity before release. The bath will consist of exposure to 3% solution of NaCl for 10-15 minutes (no greater than 20 minute exposure; pers. comm., S. Foott). Water used for the therapeutic bath will be well water at a temperature similar to receiving water temperature.

Release Sites

Suckers to be released in Upper Klamath Lake will be released in the lower Williamson River at The Nature Conservancy boat launch. This release site permits an opportunity for recapture of released fish by other researchers investigating fish use of the Williamson River delta area to verify survival of released (and marked) suckers that is not available through the use of other release sites. It will be necessary to hold fish insitu to evaluate short term survivorship. A portion of both salvage and trap and haul fish will be held for 24-48 hours in floating cages at the boat launch site when conducting the short-term survival studies. The initial portion will be 10% of the group transported for release. Fish will be assigned for immediate release or holding in an unbiased manner such as every tenth fish will be held. Both the portion of individuals to be held and the manner used to assign fish to a release or holding group will be evaluated and revised when necessary. Densities at which juvenile fish will be placed and held in floating cages at the release site will be determined through cooperation with Dr. Scott Foott, USFWS, California-Nevada Fish Health Center.

Suckers salvaged from J Canal in autumn 2008 will be transported using the methods described above before release into the Lost River below Anderson-Rose Dam or into Tule Lake from the boat ramp on the western shore of Sump 1A. Reclamation proposes salvaged suckers from J Canal only be held for a short duration to evaluate recovery from a marking technique.

Marking Released Klamath Basin Suckers

The primary indication that these relocated fish benefit the sucker populations should be a noticeable increase in recruitment to spawning age. A more indicative metric that relocating fish has a population benefit than a change in recruitment is the recruitment of relocated fish. To determine the effect of relocating fish at a population level requires relocated fish to be marked in a manner that is readily detectable when they recruit to spawning age. Presently, the only fashion to possibly validate the success of both salvage and trap and haul is to detect an increase in recruitment that may or may not be attributable to relocating fish.

Reclamation proposes to investigate marking procedures for small juvenile suckers so that both salvage and trap and haul efforts can be evaluated at a population level. Presently, passive integrated transponder (PIT) tagging techniques are not available for early season young of the year (age 0+) juvenile suckers. The PIT tag is too large to safely insert it into the body of small fish (standard length (SL) < 65 mm) while satisfying the assumption that no harm or effect to the fish as a result of marking. Water quality conditions may also influence survival of PIT tagged juvenile suckers regardless of size (pers. comm., S. VanderKooi). Reclamation proposes to investigate latex or elastomer injection or coded wire injection to ‘batch tag’ groups of early season age 0+ suckers before release. Late season age 0+ suckers may be large enough (SL > 65 mm) and water quality conditions may have improved to permit implantation of PIT tags. Other fishery biologists in the basin will be made aware of our tagging procedure in order that they may detect and report to Reclamation the recovery of a released juvenile sucker. Reclamation hopes that batch marks are retained for several years so that individual suckers can be PIT tagged when they recruit into the adult population.

References

Banner, C. (September 15) 2006. Oregon Department of Fish and Wildlife Fish Exam report CB06-232. 2p.

Banner, C. (November 30) 2007. Oregon Department of Fish and Wildlife Fish Exam report CB07-349. 2p.

Banner, C., and R. Stocking. (July 12) 2007. Oregon Department of Fish and Wildlife Fish Exam report CB07-188. 3p.

Cipriano, R; K. Beauchamp; E. Janney; S Vanderkooi; C Densmore; C Ottinger; F Panek; R Shively. 2007. Microbial distribution associated with the dermis and gills of endangered populations of Lost River and shortnose suckers from the Upper Klamath Lake, Oregon. Administrative Report; 2006 & 2007 Field and Laboratory Investigations. 29 pages.

Foott, J.S. 2004. Health monitoring of adult Lost River Sucker (*Deltistes luxatus*) and Shortnose Sucker (*Chasmistes brevirostris*) in upper Klamath Lake, Oregon, April – September 2003. ***http://www.fws.gov/canvfhc/reports***

Foott, J.S., R. Stone, and R. Fogerty. 2007. Lack of disease response in juvenile Upper Klamath Lake suckers (age 0+) to adverse water quality conditions- Pilot study August 2007. ***http://www.fws.gov/canvfhc/reports***

Perkins, D.L., J. Kann, and G.G. Scoppettone. 2000. The role of poor water quality and fish kills in the decline of endangered Lost River and shortnose suckers in Upper Klamath Lake. Final Report. U.S. Geological Survey, Biological Resources Division, Western Fisheries Research Center, Reno Field Station, Reno, Nevada.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish hatchery management. Department of the Interior. Fish and Wildlife Service. Washington, D.C.

Personal Communication

Dr. Scott Foott, USFWS, California-Nevada Fish Health Center
Scott VanderKooi, USGS, Klamath Falls Field Station.
Alex Wilkens, Bureau of Reclamation, Klamath Basin Area Office

Transport procedures for large tank

1. Rinse holding tank before filling.
2. Only fill transport tank to 80% total capacity (about 600 liters or 160 gallons) with well water.
3. A total of 3040 grams of NaCl will be added to the tank at 80% capacity (160 gallons of water) to achieve a 0.5% NaCl concentration (approximately 10 ppt).
4. Dissolved oxygen will be supplied to the tank via atmospheric air delivered to the tank through an aerator and airstones. The aerator will be adjusted until airstones releases a gentle, fine stream of bubbles. We propose to avoid bottled oxygen to prevent super-oxygenated water.
5. A commercially available slime coat will be added to transport tanks.
6. Add no more than 75 kg (165 lbs) of fish. This is equivalent to about 30 adult shortnose suckers (estimated average adult weight 2.5 kg or 5.5 lb), or about 15 adult Lost River suckers (estimated average adult weight >4kg or >8.8 lb). Total numbers of juvenile suckers in the transport tank is variable with size of fish, but should not exceed approximately 2000 total individuals. General guidelines for number of fish per unit volume of water call for 1 kg per 8 liters (one pound per gallon; Piper et al. 1982). Smaller juvenile suckers (average standard length = 35mm) are about 648 fish/lb. Medium and larger juvenile suckers (average standard lengths of 55 and 90 mm) are about 151 and 41 fish/lb (unpublished data, A. Wilkens). The size of fish and transport densities will be reviewed annually and adjusted as needed.
7. Transport tanks will remain covered while fish are present.
8. Dissolved oxygen will be continuously monitored in the transport tanks while fish are present.
9. Data to be recorded should include at a minimum: 1. time of fish collection, 2. time of sucker release, 3. temperature of collection water, 4. temperature of transport water, 5. temperature of receiving water, 6. number of mortalities during capture and transport, and 7. number of mortalities after a specified time of holding (if holding).
10. Water temperature of receiving water should be within 5.5°C (or about 10° F) of holding tank water. If the temperature difference is greater than 5.5° C (or 10° F), water should be tempered by mixing water from receiving water into the holding tank.
11. Visually inspect aeration equipment and general fish condition every 60 minutes while fish are in transport tank.
12. Transfer of fish from transport tank to receiving waters should be via a slide affixed to the tank valve to minimize drop during release or by handheld dipnets.
13. After delivery of fish to release sites, disinfect transport tank and other equipment that contacted water (airstones and tubing, nets, etc.) using 1% Virkon Aquatic (Western Chemical, Inc.; www.wchemical.com) disinfectant solution.

Transport procedures for small insulated tanks

1. Rinse insulated tanks (i.e., commercial coolers) before filling.
2. Only fill tank to 80% capacity or approximately 36.3 L in a 48 qt insulated tank with well water.
3. To develop a 0.5% NaCl concentration, 182 g of NaCl should be added to the small transport tank filled to 36.3 L (about 9.6 gallons).
4. Turn on aerator until airstone releases a gentle, fine stream of bubbles. Avoid bottled oxygen to prevent over oxygenated water.
5. A commercially available slime coat will be added to transport tanks.
6. Add no more than the equivalency of 1 lb of fish to 1 gallon of water, or no more than 2 adult suckers or 300 juvenile suckers per tank of 36.3 L (about 9.6 gallons). General guidelines for number of fish per unit volume of water call for 1 kg per 8 liters (one pound per gallon; Piper et al. 1982). Smaller juvenile suckers (average standard length = 35mm) are about 648 fish/lb. Medium and larger juvenile suckers (average standard lengths of 55 and 90 mm) are about 151 and 41 fish/lb (unpublished data, A. Wilkens). The size of fish and transport densities will be reviewed annually and adjusted as needed.
7. Transport tanks will remain covered while fish are present.
8. Water temperature of receiving water should be within 5.5°C (10° F) of holding tank water. If the temperature difference is greater than 5.5°C, water should be tempered by mixing water from receiving water into the holding tank.
9. Data to be recorded should include at a minimum: 1. time of fish collection, 2. time of sucker release, 3. temperature of collection water, 4. temperature of transport water, 5. temperature of receiving water, 6. number of mortalities during capture and transport, and 7. number of mortalities after a specified time of holding (if holding).
10. Visually inspect aeration equipment and general fish condition every 60 minutes while fish are in transport tank.
11. Water temperature of receiving water should be within 5.5°C (or about 10° F) of holding tank water. If the temperature difference is greater than 5.5° C (or 10° F), water should be tempered by mixing water from receiving water into the holding tank.
12. Transfer of fish from transport tank to receiving waters should be gentle dump of tank contents or via dipnet.
13. After delivery of fish to release sites, disinfect transport tank and other equipment that contacted water (airstones and tubing, nets, etc.) using 1% Virkon Aquatic (Western Chemical, Inc.; www.wchemical.com) disinfectant solution.

Appendix 6A: Clear Lake Reservoir End of Month Surface Elevations

Appendix 6A. Clear Lake Reservoir end of month surface elevations (Reclamation datum, feet above mean sea level).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2010-11	4,520.42	4,520.43	4,522.36	4,523.22	4,523.59	4,526.17	4,528.85	4,529.04	4,528.67	4,527.71	4,526.65	4,525.96
2009-10	4,521.86	4,521.88	4,522.09	4,522.15	4,522.26	4,522.74	4,523.03	4,522.57	4,522.19	4,522.06	4,520.94	4,520.62
2008-09	4,523.23	4,523.24	4,523.31	4,523.40	4,523.55	4,523.99	4,523.79	4,522.59	4,520.79	4,520.12	4,521.87	4,521.82
2007-08	4,523.59	4,523.57	4,523.68	4,523.94	4,524.48	4,526.61	4,527.33	4,527.27	4,526.60	4,525.35	4,524.18	4,523.40
2006-07	4,528.08	4,528.11	4,528.19	4,528.20	4,528.41	4,528.69	4,528.53	4,527.73	4,526.76	4,525.63	4,524.41	4,523.77
2005-06	4,521.68	4,522.18	4,525.30	4,527.12	4,528.23	4,529.86	4,532.32	4,532.08	4,531.30	4,530.27	4,529.14	4,528.31
2004-05	4,521.87	4,521.89	4,522.09	4,522.39	4,522.69	4,522.72	4,523.26	4,524.76	4,524.13	4,522.82	4,521.72	4,521.79
2003-04	4,521.86	4,522.07	4,522.38	4,522.82	4,524.60	4,526.29	4,526.31	4,525.69	4,524.72	4,523.42	4,520.62	4,518.34
2002-03	4,524.02	4,524.00	4,524.40	4,524.70	4,524.96	4,525.32	4,526.04	4,526.18	4,525.07	4,523.85	4,520.98	4,522.25
2001-02	4,525.60	4,525.86	4,526.52	4,526.90	4,527.35	4,527.89	4,528.51	4,528.16	4,527.19	4,526.13	4,524.90	4,524.15
2000-01	4,531.33	4,531.46	4,531.48	4,531.45	4,531.51	4,531.63	4,531.52	4,530.54	4,529.20	4,527.98	4,526.65	4,525.75
1999-00	4,534.17	4,534.07	4,534.06	4,534.45	4,535.02	4,536.12	4,536.49	4,535.98	4,535.06	4,534.06	4,532.99	4,531.54
1998-99	4,535.21	4,535.63	4,536.16	4,536.52	4,536.82	4,537.84	4,537.88	4,537.62	4,536.90	4,535.94	4,535.04	4,534.35
1997-98	4,534.35	4,534.32	4,534.36	4,536.02	4,536.86	4,538.57	4,538.48	4,538.53	4,538.30	4,537.39	4,536.34	4,535.64
1996-97	4,533.78	4,533.80	4,535.90	4,537.67	4,537.89	4,538.20	4,538.30	4,537.81	4,537.00	4,536.20	4,535.20	4,534.60
1995-96	4,529.94	4,530.00	4,530.45	4,531.26	4,535.62	4,537.13	4,537.45	4,537.40	4,536.64	4,535.65	4,534.71	4,534.00
1994-95	4,521.54	4,521.65	4,521.96	4,525.89	4,527.49	4,531.23	4,532.80	4,533.46	4,532.98	4,532.00	4,531.01	4,530.24
1993-94	4,526.04	4,525.96	4,526.05	4,526.09	4,526.20	4,526.30	4,525.84	4,525.39	4,524.49	4,523.16	4,521.43	4,521.70
1992-93	4,519.30	4,519.29	4,519.35	4,519.40	4,521.46	4,527.98	4,529.40	4,529.12	4,528.54	4,527.63	4,526.86	4,526.16
1991-92	4,522.50	4,522.51	4,522.80	4,522.85	4,523.00	4,522.84	4,522.75	4,521.77	4,521.18	4,520.44	4,519.82	4,519.42
1990-91	4,526.78	4,526.76	4,526.70	4,526.98	4,527.00	4,527.10	4,526.90	4,526.42	4,525.65	4,524.45	4,523.52	4,522.75
1989-90	4,531.82	4,530.80	4,530.82	4,530.95	4,531.05	4,531.54	4,531.24	4,530.55	4,529.90	4,528.78	4,527.74	4,527.08
1988-89	4,528.30	4,528.30	4,528.34	4,528.67	4,529.00	4,533.88	4,534.82	4,534.40	4,533.68	4,532.47	4,531.54	4,531.00
1987-88	4,531.17	4,531.10	4,531.30	4,531.42	4,532.00	4,532.68	4,532.54	4,532.18	4,531.20	4,530.20	4,529.13	4,528.30
1986-87	4,534.97	4,534.85	4,534.83	4,535.08	4,535.20	4,535.66	4,535.35	4,534.50	4,533.85	4,533.05	4,532.09	4,531.41

Appendix 6A (continued). Clear Lake Reservoir end of month surface elevations (Reclamation datum, feet above mean sea level).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1985-86	4,534.11	4,534.20	4,534.14	4,534.40	4,537.80	4,539.55	4,539.27	4,538.78	4,537.85	4,536.76	4,535.63	4,535.14
1984-85	4,536.41	4,536.86	4,536.88	4,536.88	4,537.45	4,538.24	4,538.52	4,537.85	4,536.85	4,535.65	4,534.64	4,534.30
1983-84	4,537.02	4,537.05	4,539.43	4,539.60	4,540.11	4,541.63	4,542.28	4,541.89	4,541.27	4,540.33	4,538.97	4,537.86
1982-83	4,532.78	4,532.85	4,533.02	4,534.54	4,536.42	4,539.26	4,540.40	4,540.72	4,540.00	4,538.94	4,538.00	4,537.27
1981-82	4,524.42	4,525.95	4,528.48	4,529.02	4,532.40	4,533.70	4,536.60	4,536.14	4,535.45	4,534.65	4,533.50	4,532.71
1980-81	4,527.20	4,527.26	4,527.21	4,527.32	4,527.73	4,528.70	4,528.85	4,528.27	4,527.42	4,526.24	4,525.10	4,524.36
1979-80	4,524.33	4,524.55	4,524.85	4,527.26	4,529.66	4,530.70	4,530.94	4,530.61	4,530.30	4,529.05	4,528.10	4,527.41
1978-79	4,526.96	4,527.00	4,527.00	4,527.16	4,527.40	4,528.60	4,528.78	4,528.12	4,527.32	4,526.06	4,525.10	4,524.38
1977-78	4,525.95	4,525.96	4,526.58	4,528.10	4,528.55	4,529.57	4,531.09	4,530.80	4,529.90	4,528.86	4,527.88	4,527.20
1976-77	4,530.22	4,530.15	4,530.17	4,530.16	4,530.20	4,530.17	4,529.60	4,529.34	4,528.54	4,527.43	4,526.58	4,526.39
1975-76	4,533.60	4,533.57	4,533.61	4,533.68	4,533.70	4,534.27	4,534.24	4,533.35	4,532.47	4,531.45	4,531.20	4,530.37
1974-75	4,533.10	4,533.06	4,533.10	4,533.26	4,533.74	4,535.82	4,536.86	4,537.53	4,536.55	4,535.55	4,534.63	4,533.77
1973-74	4,530.73	4,531.16	4,532.34	4,534.00	4,534.18	4,536.90	4,537.94	4,537.27	4,536.25	4,535.30	4,534.34	4,533.41
1972-73	4,533.48	4,533.51	4,533.78	4,535.15	4,534.70	4,535.24	4,535.34	4,534.70	4,533.76	4,532.62	4,531.46	4,530.88
1971-72	4,533.17	4,533.18	4,533.28	4,534.33	4,535.82	4,538.92	4,539.14	4,538.40	4,537.30	4,535.84	4,534.52	4,533.56
1970-71	4,532.60	4,532.96	4,533.78	4,535.44	4,536.02	4,538.48	4,539.26	4,539.10	4,538.55	4,537.40	4,535.63	4,533.58
1969-70	4,531.23	4,531.20	4,531.97	4,535.82	4,536.50	4,537.45	4,537.15	4,536.50	4,535.84	4,534.70	4,533.65	4,532.86
1968-69	4,525.72	4,525.82	4,526.80	4,528.60	4,529.82	4,531.33	4,535.52	4,534.95	4,534.26	4,533.36	4,532.14	4,531.37
1967-68	4,528.88	4,528.80	4,528.79	4,528.83	4,530.31	4,530.60	4,530.07	4,529.51	4,528.60	4,527.23	4,526.58	4,525.82
1966-67	4,527.05	4,527.31	4,528.20	4,528.56	4,529.32	4,530.60	4,531.52	4,532.60	4,532.00	4,530.90	4,529.86	4,529.08
1965-66	4,530.47	4,530.55	4,530.50	4,530.62	4,530.70	4,531.63	4,531.70	4,531.12	4,530.27	4,529.05	4,527.90	4,527.34
1964-65	4,524.20	4,524.24	4,527.80	4,531.20	4,533.00	4,533.80	4,534.38	4,533.65	4,533.20	4,532.20	4,531.45	4,530.72
1963-64	4,524.00	4,524.05	4,524.15	4,524.30	4,524.30	4,524.90	4,527.86	4,527.40	4,527.34	4,526.20	4,525.14	4,524.45

Appendix 6A (continued). Clear Lake Reservoir end of month surface elevations (Reclamation datum, feet above mean sea level).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1962-63	4,524.33	4,524.50	4,525.23	4,525.26	4,526.35	4,526.57	4,527.52	4,527.70	4,526.70	4,525.70	4,524.70	4,524.12
1961-62	4,521.33	4,521.47	4,521.70	4,521.87	4,523.37	4,524.25	4,525.50	4,525.10	4,524.08	4,522.88	4,521.90	4,521.28
1960-61	4,524.60	4,524.63	4,524.99	4,524.97	4,525.43	4,525.78	4,525.63	4,525.28	4,524.40	4,523.08	4,522.16	4,521.44
1959-60	4,527.85	4,527.77	4,527.76	4,527.81	4,528.08	4,528.85	4,529.10	4,528.86	4,527.83	4,526.48	4,525.49	4,524.80
1958-59	4,533.41	4,533.35	4,533.38	4,533.49	4,533.60	4,533.53	4,533.04	4,532.44	4,531.34	4,530.10	4,529.03	4,528.15
1957-58	4,533.42	4,533.70	4,534.30	4,534.78	4,538.11	4,539.05	4,540.72	4,540.14	4,538.90	4,537.50	4,535.90	4,534.51
1956-57	4,534.98	4,533.80	4,534.28	4,534.30	4,536.12	4,538.31	4,538.26	4,537.80	4,536.62	4,535.36	4,534.20	4,533.42
1955-56	4,527.30	4,527.52	4,530.83	4,535.13	4,536.03	4,539.73	4,541.61	4,541.21	4,540.04	4,538.45	4,537.03	4,535.81
1954-55	4,530.51	4,530.57	4,530.60	4,530.66	4,530.78	4,531.36	4,532.10	4,531.36	4,530.44	4,529.36	4,528.36	4,527.50
1953-54	4,531.37	4,531.50	4,531.80	4,531.96	4,533.45	4,535.10	4,535.33	4,534.49	4,533.90	4,532.69	4,531.64	4,530.86
1952-53	4,529.37	4,529.22	4,529.50	4,532.09	4,532.81	4,533.39	4,533.81	4,534.60	4,534.52	4,533.32	4,532.31	4,531.61
1951-52	4,522.58	4,522.54	4,522.93	4,523.25	4,523.97	4,527.59	4,533.14	4,533.00	4,532.23	4,531.38	4,530.37	4,529.68
1950-51	4,523.87	4,523.87	4,524.40	4,524.59	4,525.93	4,526.70	4,527.02	4,526.84	4,525.63	4,524.34	4,523.31	4,522.57
1949-50	4,524.60	4,524.57	4,524.56	4,524.75	4,525.81	4,527.21	4,527.95	4,527.37	4,526.67	4,525.46	4,524.47	4,523.88
1948-49	4,526.36	4,526.28	4,526.44	4,526.50	4,526.64	4,528.36	4,528.95	4,528.49	4,527.62	4,526.47	4,525.39	4,524.77
1947-48	4,526.71	4,526.66	4,526.67	4,527.00	4,527.08	4,527.37	4,528.57	4,529.31	4,528.87	4,527.87	4,526.99	4,526.51
1946-47	4,529.65	4,529.71	4,529.84	4,529.85	4,530.23	4,530.95	4,530.66	4,529.92	4,529.44	4,528.33	4,527.46	4,526.84
1945-46	4,530.92	4,531.19	4,531.51	4,532.13	4,531.75	4,533.47	4,534.14	4,533.47	4,532.59	4,531.62	4,530.65	4,529.93
1944-45	4,530.44	4,530.67	4,530.78	4,531.02	4,533.35	4,533.54	4,533.95	4,534.07	4,533.91	4,532.44	4,531.89	4,531.06
1943-44	4,534.00	4,533.97	4,533.94	4,533.96	4,533.98	4,534.07	4,534.37	4,533.72	4,533.25	4,532.22	4,531.27	4,530.60
1942-43	4,531.50	4,531.53	4,531.80	4,532.11	4,532.50	4,536.92	4,537.81	4,537.62	4,536.91	4,535.94	4,534.96	4,534.27
1941-42	4,529.08	4,529.09	4,530.26	4,531.99	4,533.43	4,534.45	4,534.93	4,535.10	4,534.37	4,533.31	4,532.38	4,531.77
1940-41	4,529.51	4,529.47	4,529.65	4,529.95	4,531.75	4,532.37	4,532.28	4,531.88	4,531.30	4,530.38	4,529.70	4,529.21

Appendix 6A (continued). Clear Lake Reservoir end of month surface elevations (Reclamation datum, feet above mean sea level).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1939-40	4,527.61	4,527.54	4,527.91	4,528.92	4,531.63	4,533.27	4,533.70	4,533.05	4,532.00	4,531.00	4,530.03	4,529.63
1938-39	4,531.11	4,531.10	4,531.05	4,531.08	4,531.08	4,532.00	4,531.65	4,530.91	4,530.04	4,529.12	4,528.17	4,527.78
1937-38	4,521.60	4,522.00	4,524.65	4,524.90	4,525.65	4,530.58	4,534.85	4,534.80	4,533.80	4,532.95	4,531.95	4,531.32
1936-37	4,520.90	4,520.80	4,520.80	4,521.00	4,521.17	4,525.70	4,525.05	4,524.40	4,523.80	4,522.90	4,522.10	4,521.60
1935-36	4,518.50	4,518.50	4,518.70	4,519.45	4,521.60	4,523.30	4,524.35	4,524.00	4,523.36	4,522.40	4,521.60	4,521.15
1934-35	4,514.40	4,514.85	4,515.23	4,515.30	4,516.30	4,517.50	4,522.10	4,521.60	4,520.70	4,519.90	4,519.10	4,518.60
1933-34	4,517.70	4,517.65	4,517.90	4,518.05	4,518.33	4,518.10	4,517.67	4,517.00	4,516.41	4,515.62	4,515.00	4,514.50
1932-33	4,519.75	4,519.70	4,519.70	4,519.80	4,519.90	4,520.80	4,521.40	4,521.35	4,520.15	4,519.00	4,518.12	4,517.70
1931-32	4,517.05	4,517.08	4,517.30	4,517.45	4,517.53	4,523.60	4,523.65	4,523.25	4,522.32	4,521.40	4,520.50	4,519.84
1930-31	4,521.82	4,521.81	4,521.80	4,521.80	4,521.80	4,521.60	4,521.35	4,520.60	4,519.60	4,518.25	4,517.60	4,517.20
1929-30	4,522.88	4,522.84	4,523.02	4,523.22	4,524.95	4,525.85	4,525.60	4,524.90	4,523.76	4,522.63	4,522.04	4,521.84
1928-29	4,526.35	4,526.40	4,526.45	4,526.58	4,526.77	4,527.14	4,527.50	4,526.66	4,525.94	4,524.74	4,523.60	4,522.96
1927-28	4,525.52	4,525.88	4,526.07	4,526.07	4,526.68	4,527.62	4,529.96	4,530.65	4,530.00	4,529.03	4,528.03	4,527.15
1926-27	4,522.66	4,523.30	4,523.55	4,524.02	4,525.35	4,527.18	4,528.75	4,528.75	4,527.97	4,527.00	4,526.10	4,525.64
1925-26	4,526.71	4,526.75	4,526.83	4,526.83	4,527.16	4,527.10	4,526.71	4,526.00	4,524.86	4,523.81	4,523.00	4,522.66
1924-25	4,528.30	4,528.31	4,528.46	4,528.69	4,529.60	4,529.75	4,529.64	4,529.39	4,528.93	4,528.00	4,527.20	4,526.86
1923-24	4,534.30	4,534.20	4,534.16	4,534.19	4,534.42	4,534.23	4,533.92	4,533.28	4,532.39	4,531.38	4,530.20	4,529.06
1922-23	4,536.32	4,536.03	4,536.03	4,536.17	4,536.27	4,536.71	4,537.00	4,536.56	4,536.10	4,535.79	4,534.99	4,534.48
1921-22	4,535.00	4,534.95	4,534.91	4,535.00	4,535.13	4,535.74	4,538.80	4,538.93	4,538.31	4,537.61	4,536.99	4,536.60
1920-21	4,531.47	4,531.65	4,532.02	4,533.70	4,535.60	4,537.74	4,538.18	4,537.86	4,537.44	4,536.54	4,535.94	4,535.32
1919-20	4,534.00	4,533.90	4,533.90	4,533.90	4,533.83	4,534.01	4,534.22	4,533.75	4,533.17	4,532.52	4,531.94	4,531.55
1918-19	4,533.48	4,533.45	4,533.45	4,534.45	4,533.97	4,535.12	4,537.40	4,536.80	4,536.02	4,535.30	4,534.60	4,534.20
1917-18	4,536.48	4,536.38	4,536.25	4,536.20	4,536.18	4,536.80	4,536.59	4,536.10	4,535.37	4,534.60	4,533.98	4,533.70

Appendix 6A (continued). Clear Lake Reservoir end of month surface elevations (Reclamation datum, feet above mean sea level).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1916-17	4,532.70	4,532.66	4,532.12	4,532.25	4,532.25	4,533.70	4,539.04	4,539.60	4,538.84	4,538.04	4,537.50	4,536.81
1915-16	4,531.85	4,531.90	4,531.88	4,532.02	4,533.45	4,535.15	4,535.60	4,535.20	4,534.65	4,534.05	4,533.35	4,532.95
1914-15	4,533.27	4,533.23	4,533.20	4,533.20	4,534.00	4,535.00	4,534.85	4,534.65	4,533.97	4,533.30	4,532.68	4,532.15
1913-14	4,529.80	4,529.75	4,529.75	4,531.30	4,532.15	4,535.80	4,536.24	4,535.83	4,535.44	4,534.77	4,534.00	4,533.40
1912-13	4,529.25	4,529.20	4,529.25	4,529.30	4,539.30	4,529.85	4,531.95	4,531.85	4,531.30	4,531.10	4,530.65	4,530.05
1911-12	4,529.75	4,529.65	4,529.80	4,530.00	4,530.50	4,530.80	4,531.30	4,531.40	4,531.10	4,530.65	4,530.20	4,529.55
1910-11	4,524.12	4,524.24	4,525.90	4,526.15	4,526.35	4,529.30	4,532.35	4,532.05	4,531.75	4,531.10	4,530.55	4,530.00
1909-10	NA	NA	NA	4,523.60	4,525.40	4,527.40	4,527.10	4,526.70	4,526.00	4,525.40	4,524.60	4,524.28
1908-09	4,529.00	4,528.90	4,528.85	4,529.80	4,530.30	4,531.35	4,532.05	4,531.45	4,530.55	4,529.35	4,528.30	4,527.65
1907-08	4,532.70	4,532.60	4,532.75	4,533.20	4,533.25	4,533.60	4,533.60	4,533.00	4,531.95	4,530.75	4,529.70	4,529.10
1906-07	4,525.85	4,525.80	4,526.25	4,527.00	4,530.00	4,533.90	4,536.50	4,526.25	4,535.50	4,534.30	4,533.25	4,532.75
1905-06	4,523.85	4,523.80	4,523.80	4,523.80	4,524.15	4,526.75	4,529.95	4,529.80	4,529.00	4,527.80	4,526.65	4,526.00
1904-05	4,522.10	4,522.20	4,522.30	4,522.85	4,523.65	4,524.45	4,524.75	4,524.70	4,524.70	4,524.40	4,524.10	4,523.95
1903-04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,522.00	4,522.00

End of Appendix 6A

Appendix 6B: Gerber Reservoir Observed End of Month Surface Elevations

Appendix 6B. Gerber Reservoir observed end of month surface elevations (Reclamation datum, feet above mean sea level).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2011-12	4,819.97	4,819.94	4,819.99	4,820.26	4,820.82	4,824.79						
2010-11	4,803.18	4,803.22	4,809.08	4,814.44	4,815.22	4,821.88	4,830.13	4,830.10	4,828.25	4,825.39	4,822.56	4,820.12
2009-10	4,812.24	4,812.07	4,812.80	4,813.34	4,815.24	4,816.12	4,817.79	4,817.46	4,815.30	4,811.40	4,807.20	4,803.28
2008-09	4,820.56	4,820.52	4,820.87	4,820.74	4,821.68	4,824.58	4,825.00	4,823.49	4,821.92	4,818.72	4,815.56	4,812.40
2007-08	4,819.80	4,819.81	4,819.96	4,820.37	4,820.65	4,826.60	4,831.86	4,830.70	4,828.98	4,826.18	4,823.33	4,820.81
2006-07	4,824.23	4,824.50	4,825.92	4,825.98	4,828.30	4,832.27	4,832.60	4,830.58	4,828.06	4,825.25	4,822.27	4,819.82
2005-06	4,807.44	4,809.23	4,820.64	4,826.60	4,831.32	4,835.88	4,836.22	4,834.60	4,832.57	4,829.76	4,827.06	4,824.57
2004-05	4,805.69	4,805.68	4,808.30	4,808.30	4,810.72	4,812.04	4,813.94	4,821.27	4,819.14	4,815.37	4,811.34	4,807.54
2003-04	4,808.25	4,808.28	4,808.99	4,810.41	4,815.39	4,822.44	4,822.33	4,820.15	4,817.26	4,813.52	4,809.36	4,805.98
2002-03	4,808.26	4,808.35	4,809.26	4,813.21	4,814.12	4,816.69	4,821.17	4,822.45	4,819.08	4,815.40	4,811.83	4,808.61
2001-02	4,810.59	4,810.86	4,811.35	4,816.32	4,818.32	4,822.69	4,824.50	4,822.84	4,819.76	4,816.10	4,812.30	4,808.50
2000-01	4,823.07	4,823.13	4,823.19	4,823.21	4,823.41	4,825.38	4,825.75	4,823.01	4,819.96	4,816.85	4,813.28	4,810.87
1999-00	4,823.80	4,823.56	4,823.68	4,825.50	4,828.48	4,832.54	4,835.00	4,833.46	4,830.73	4,827.98	4,825.11	4,823.40
1998-99	4,827.45	4,829.68	4,830.94	4,832.38	4,830.70	4,831.14	4,834.24	4,833.97	4,831.84	4,828.83	4,826.20	4,823.80
1997-98	4,824.40	4,824.42	4,824.56	4,830.82	4,833.76	4,836.19	4,835.65	4,836.29	4,835.16	4,832.68	4,830.39	4,828.00
1996-97	4,826.18	4,826.60	4,834.60	4,834.18	4,834.10	4,835.56	4,835.55	4,833.64	4,831.62	4,828.96	4,826.51	4,824.36
1995-96	4,825.39	4,825.40	4,827.50	4,829.67	4,835.04	4,835.88	4,835.83	4,835.72	4,833.54	4,830.97	4,828.42	4,826.36
1994-95	4,806.59	4,806.74	4,807.08	4,816.63	4,822.02	4,832.16	4,835.91	4,835.13	4,833.88	4,831.16	4,828.27	4,825.70
1993-94	4,821.96	4,821.96	4,822.20	4,822.32	4,822.94	4,823.30	4,822.48	4,820.80	4,817.81	4,814.08	4,810.16	4,806.78
1992-93	4,796.62	4,796.62	4,797.06	4,798.79	4,802.24	4,828.00	4,831.92	4,830.34	4,829.60	4,826.84	4,824.49	4,822.04
1991-92	4,797.98	4,797.96	4,798.04	4,798.18	4,800.74	4,801.28	4,801.14	4,798.86	4,798.36	4,797.73	4,797.01	4,796.52
1990-91	4,804.38	4,804.32	4,804.40	4,804.54	4,804.82	4,804.18	4,808.26	4,808.10	4,803.60	4,799.22	4,798.60	4,798.08
1989-90	4,815.18	4,815.16	4,815.20	4,816.58	4,817.48	4,821.33	4,821.20	4,818.94	4,816.12	4,812.25	4,808.70	4,804.56
1988-89	4,802.20	4,803.98	4,804.30	4,804.40	4,805.42	4,826.42	4,828.66	4,827.00	4,824.18	4,820.81	4,818.00	4,815.26

Appendix 6B (continued). Gerber Reservoir observed end of month surface elevations (Reclamation datum, feet above mean sea level).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1987-88	4,813.24	4,813.18	4,813.54	4,814.00	4,815.80	4,819.12	4,819.53	4,817.53	4,815.00	4,810.95	4,806.90	4,802.40
1986-87	4,822.95	4,822.88	4,823.00	4,823.10	4,824.78	4,827.90	4,827.18	4,824.65	4,822.30	4,819.68	4,816.32	4,813.47
1985-86	4,823.47	4,823.51	4,823.58	4,825.91	4,834.07	4,835.60	4,834.93	4,833.32	4,830.58	4,827.68	4,824.54	4,823.10
1984-85	4,825.85	4,828.12	4,828.50	4,828.37	4,828.90	4,833.88	4,835.49	4,833.58	4,830.98	4,827.95	4,824.90	4,823.62
1983-84	4,826.26	4,826.92	4,826.82	4,824.64	4,826.50	4,836.19	4,835.80	4,834.85	4,833.15	4,830.25	4,827.68	4,825.48
1982-83	4,826.07	4,826.31	4,827.60	4,829.55	4,830.90	4,834.40	4,836.48	4,835.04	4,833.18	4,830.95	4,828.88	4,826.88
1981-82	4,804.44	4,811.50	4,821.60	4,822.20	4,833.50	4,835.85	4,835.90	4,834.58	4,832.76	4,830.70	4,827.94	4,825.93
1980-81	4,814.15	4,814.18	4,814.68	4,814.80	4,818.00	4,820.82	4,821.40	4,819.10	4,816.20	4,812.40	4,807.98	4,804.24
1979-80	4,805.72	4,807.30	4,809.00	4,817.26	4,824.18	4,826.15	4,827.05	4,825.00	4,822.80	4,819.80	4,816.50	4,814.23
1978-79	4,815.44	4,815.46	4,815.47	4,816.82	4,817.82	4,822.06	4,822.00	4,820.18	4,816.46	4,812.30	4,809.00	4,805.64
1977-78	4,802.42	4,804.40	4,809.17	4,816.38	4,819.01	4,824.76	4,828.17	4,827.00	4,824.10	4,821.08	4,817.98	4,815.70
1976-77	4,817.45	4,817.36	4,817.40	4,817.40	4,817.50	4,817.70	4,816.52	4,815.17	4,812.14	4,807.90	4,804.12	4,802.50
1975-76	4,822.66	4,822.80	4,823.63	4,823.70	4,824.69	4,828.38	4,830.25	4,827.30	4,824.52	4,821.15	4,820.48	4,817.76
1974-75	4,820.08	4,820.10	4,820.49	4,820.68	4,821.34	4,825.47	4,833.58	4,834.87	4,831.68	4,828.62	4,825.58	4,822.70
1973-74	4,812.98	4,815.62	4,820.00	4,824.17	4,824.77	4,833.27	4,834.84	4,832.90	4,829.73	4,827.04	4,823.89	4,820.76
1972-73	4,821.20	4,821.43	4,822.99	4,824.02	4,825.56	4,828.32	4,829.26	4,826.56	4,823.14	4,819.34	4,815.46	4,813.05
1970-72	4,824.20	4,824.41	4,824.70	4,826.55	4,833.04	4,835.07	4,835.50	4,833.15	4,830.22	4,826.68	4,823.39	4,821.22
1970-71	4,821.49	4,823.04	4,825.39	4,829.46	4,831.46	4,834.49	4,835.50	4,834.86	4,832.96	4,830.21	4,826.94	4,824.38
1969-70	4,821.80	4,821.81	4,824.60	4,832.08	4,832.03	4,835.00	4,834.59	4,832.57	4,830.03	4,826.78	4,823.64	4,821.63
1968-69	4,809.20	4,809.74	4,811.45	4,813.95	4,815.95	4,821.84	4,834.39	4,832.56	4,830.70	4,827.56	4,824.29	4,822.06
1967-68	4,820.62	4,820.50	4,820.62	4,820.85	4,825.65	4,825.91	4,824.71	4,822.84	4,819.52	4,815.48	4,812.90	4,809.64
1966-67	4,814.62	4,815.24	4,817.83	4,818.90	4,821.25	4,826.07	4,829.68	4,832.07	4,829.70	4,826.50	4,823.32	4,820.88

Appendix 6B (continued). Gerber Reservoir observed end of month surface elevations (Reclamation datum, feet above mean sea level).

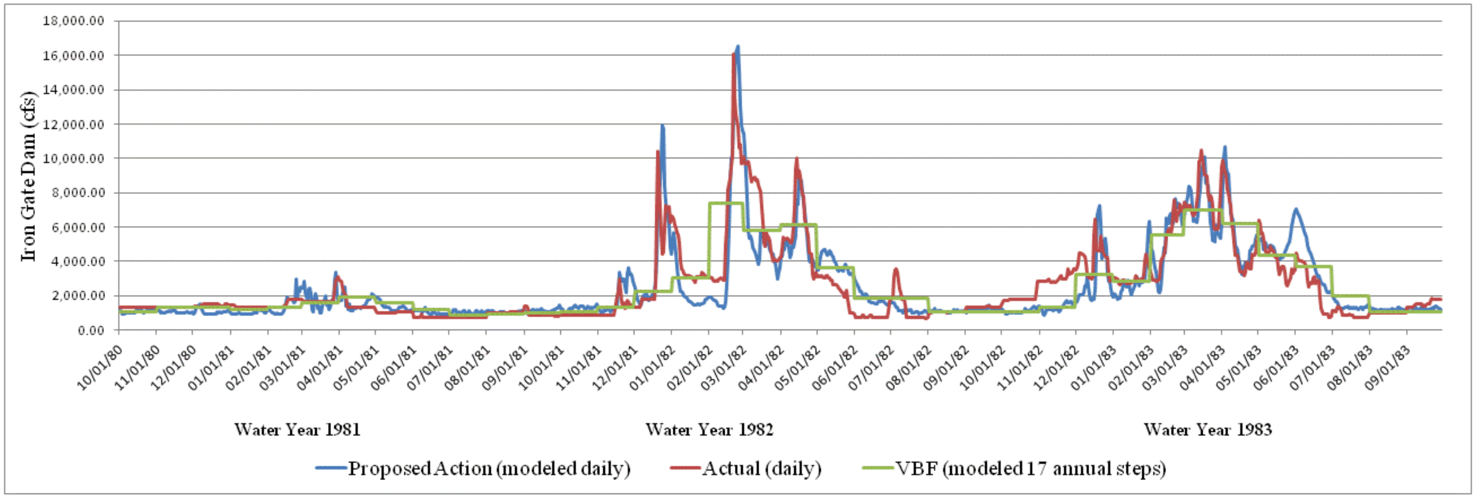
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1965-66	4,822.70	4,822.83	4,822.85	4,823.14	4,823.21	4,828.30	4,828.94	4,826.32	4,823.91	4,820.80	4,817.50	4,815.38
1964-65	4,816.58	4,816.85	4,831.40	4,829.70	4,829.02	4,831.75	4,833.95	4,831.70	4,830.00	4,826.76	4,825.00	4,822.90
1963-64	4,817.26	4,817.57	4,817.66	4,818.10	4,818.12	4,818.80	4,827.70	4,825.90	4,826.10	4,822.70	4,819.70	4,817.20
1962-63	4,809.67	4,810.50	4,814.38	4,814.80	4,819.92	4,821.30	4,827.30	4,828.00	4,825.45	4,822.65	4,819.65	4,817.90
1961-62	4,794.27	4,795.93	4,798.80	4,799.14	4,803.80	4,809.00	4,818.87	4,817.47	4,814.10	4,809.85	4,805.60	4,801.05
1960-61	4,796.53	4,797.17	4,801.25	4,802.34	4,807.64	4,811.30	4,812.37	4,810.35	4,807.88	4,804.13	4,801.24	4,794.47
1959-60	4,801.01	4,800.56	4,800.52	4,800.64	4,805.36	4,813.50	4,815.07	4,815.26	4,811.74	4,806.92	4,802.52	4,796.98
1958-59	4,820.80	4,820.64	4,820.63	4,821.71	4,822.74	4,824.22	4,822.88	4,820.35	4,815.76	4,810.25	4,805.51	4,802.16
1957-58	4,821.05	4,822.75	4,825.00	4,821.05	4,822.75	4,825.00	4,825.70	4,834.82	4,833.38	4,835.30	4,833.25	4,831.24
1956-57	4,820.82	4,821.46	4,823.06	4,823.20	4,829.65	4,833.55	4,834.97	4,834.30	4,830.92	4,827.06	4,823.30	4,820.52
1955-56	4,803.38	4,804.90	4,821.50	4,825.57	4,823.44	4,830.74	4,832.32	4,832.90	4,830.30	4,826.72	4,823.39	4,820.62
1954-55	4,814.20	4,814.29	4,814.27	4,814.39	4,814.46	4,818.07	4,821.42	4,819.47	4,815.51	4,811.38	4,816.58	4,804.02
1953-54	4,822.00	4,822.81	4,822.29	4,821.03	4,823.05	4,829.63	4,831.64	4,828.39	4,825.88	4,821.68	4,817.84	4,815.25
1952-53	4,818.87	4,818.77	4,819.24	4,825.25	4,827.08	4,830.77	4,831.94	4,833.07	4,832.19	4,828.25	4,824.84	4,822.62
1951-52	4,810.49	4,810.77	4,812.26	4,812.75	4,811.60	4,813.97	4,831.86	4,830.96	4,828.60	4,825.34	4,821.99	4,819.66
1950-51	4,806.57	4,807.41	4,813.10	4,813.56	4,820.09	4,824.98	4,825.72	4,825.24	4,821.44	4,817.19	4,813.65	4,810.44
1949-50	4,806.88	4,806.92	4,807.03	4,809.10	4,814.13	4,819.88	4,823.04	4,820.98	4,818.00	4,813.14	4,809.01	4,806.31
1948-49	4,810.17	4,810.30	4,810.66	4,808.67	4,807.79	4,816.60	4,821.81	4,820.50	4,817.64	4,813.48	4,809.75	4,806.89
1947-48	4,808.31	4,808.35	4,808.46	4,811.72	4,812.74	4,815.11	4,819.50	4,820.47	4,818.88	4,815.14	4,812.07	4,810.33
1946-47	4,813.64	4,813.94	4,814.86	4,815.19	4,818.07	4,820.06	4,820.09	4,817.78	4,816.67	4,812.98	4,809.76	4,808.42
1945-46	4,821.02	4,821.76	4,822.65	4,816.13	4,812.71	4,823.19	4,827.81	4,825.45	4,822.57	4,819.17	4,815.97	4,813.94
1944-45	4,813.96	4,814.36	4,815.39	4,817.11	4,823.28	4,825.76	4,828.83	4,830.78	4,829.62	4,826.42	4,823.31	4,821.24
1943-44	4,820.53	4,820.61	4,820.66	4,820.79	4,820.98	4,823.90	4,824.88	4,822.55	4,821.54	4,818.79	4,815.94	4,814.26

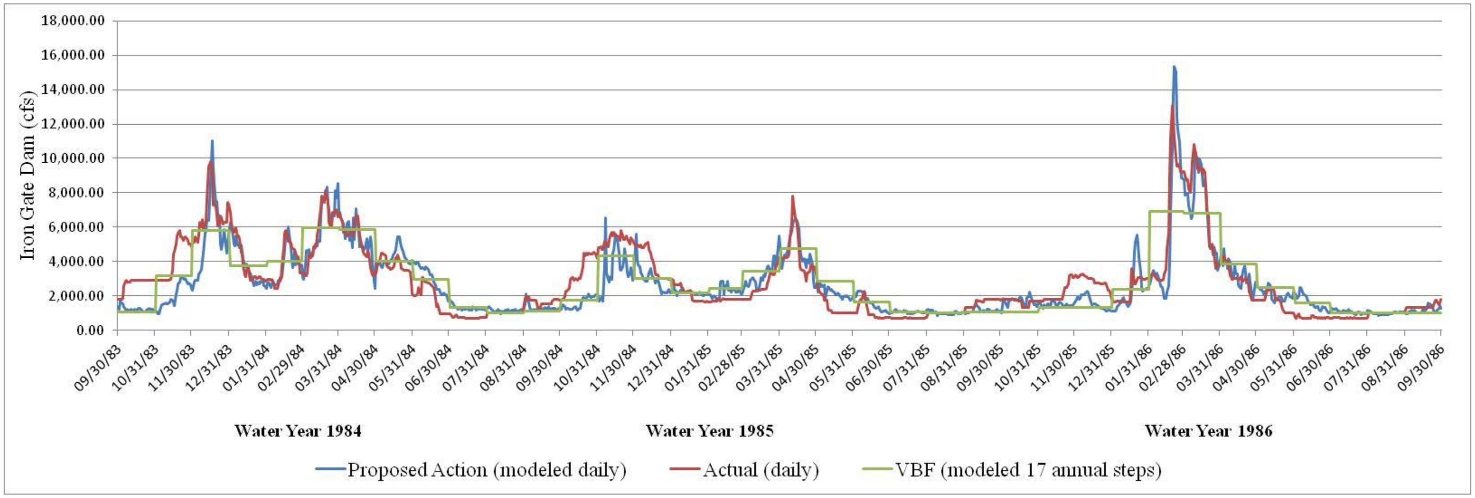
Appendix 6B (continued). Gerber Reservoir observed end of month surface elevations (Reclamation datum, feet above mean sea level).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1942-43	4,819.42	4,820.94	4,822.45	4,818.96	4,812.08	4,830.35	4,830.08	4,829.56	4,828.04	4,825.39	4,822.66	4,820.99
1927-28	4,822.28	4,821.88	4,819.86	4,817.75	4,820.88	4,826.97	4,829.10	4,827.01	4,824.55	4,822.90	4,820.73	4,818.50
1926-27	4,798.22	4,805.50	4,808.86	4,811.93	4,816.80	4,825.55	4,830.85	4,830.88	4,829.56	4,827.96	4,826.38	4,824.45
1925-26	4,804.98	4,804.95	4,805.41	4,805.46	4,808.55	4,809.12	4,808.80	4,806.90	4,804.30	4,802.06	4,800.15	4,798.45
1941-42	4,817.55	4,817.68	4,820.48	4,820.36	4,819.94	4,825.09	4,827.32	4,828.67	4,826.74	4,823.98	4,821.54	4,820.02
1940-41	4,819.55	4,819.65	4,820.28	4,820.68	4,822.98	4,826.49	4,826.55	4,825.00	4,823.28	4,820.69	4,818.72	4,817.64
1939-40	4,812.39	4,812.30	4,814.18	4,817.85	4,825.66	4,831.60	4,830.13	4,828.16	4,825.55	4,822.83	4,820.54	4,819.60
1938-39	4,817.05	4,817.23	4,817.65	4,817.74	4,817.90	4,823.98	4,823.45	4,821.20	4,818.70	4,816.25	4,813.66	4,812.53
1937-38	4,818.20	4,819.05	4,821.47	4,820.77	4,817.42	4,818.12	4,831.58	4,826.93	4,824.55	4,821.65	4,819.07	4,817.31
1936-37	4,818.04	4,817.74	4,817.81	4,817.90	4,817.60	4,820.96	4,829.46	4,828.11	4,826.01	4,823.24	4,820.80	4,818.89
1935-36	4,816.52	4,816.51	4,816.64	4,817.44	4,820.30	4,828.11	4,830.30	4,827.28	4,824.50	4,821.92	4,820.00	4,818.72
1934-35	4,803.26	4,804.12	4,805.79	4,806.08	4,808.28	4,813.66	4,824.40	4,823.63	4,821.57	4,819.87	4,818.13	4,816.78
1933-34	4,811.52	4,811.40	4,811.63	4,813.20	4,814.49	4,814.95	4,814.25	4,812.35	4,810.22	4,807.39	4,804.98	4,803.35
1932-33	4,811.18	4,811.13	4,811.17	4,811.34	4,811.40	4,813.05	4,817.54	4,818.85	4,816.70	4,814.58	4,812.79	4,811.65
1931-32	4,794.81	4,795.11	4,795.29	4,795.71	4,796.09	4,817.58	4,819.11	4,818.49	4,816.96	4,814.82	4,812.97	4,811.68
1930-31	4,806.99	4,807.02	4,807.04	4,807.35	4,807.70	4,809.13	4,809.00	4,807.39	4,804.31	4,801.68	4,798.80	4,795.77
1929-30	4,811.16	4,811.00	4,811.80	4,812.04	4,816.85	4,818.63	4,818.70	4,817.08	4,814.58	4,811.82	4,808.90	4,807.16
1928-29	4,816.99	4,816.11	4,816.25	4,816.36	4,816.44	4,819.54	4,820.97	4,819.34	4,817.28	4,814.88	4,812.92	4,811.65
1924-25	NA	NA	NA	4,797.70	4,805.00	4,806.50	4,808.90	4,809.20	4,808.50	4,806.90	4,805.80	4,805.10

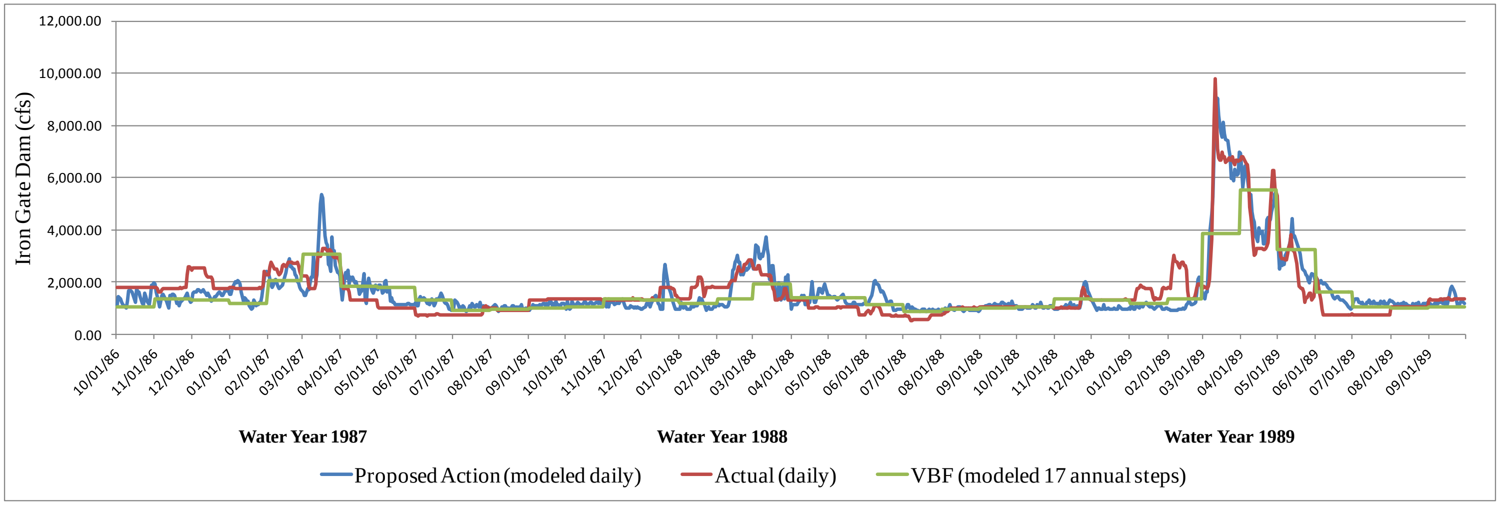
Appendix 8A: Coho Salmon

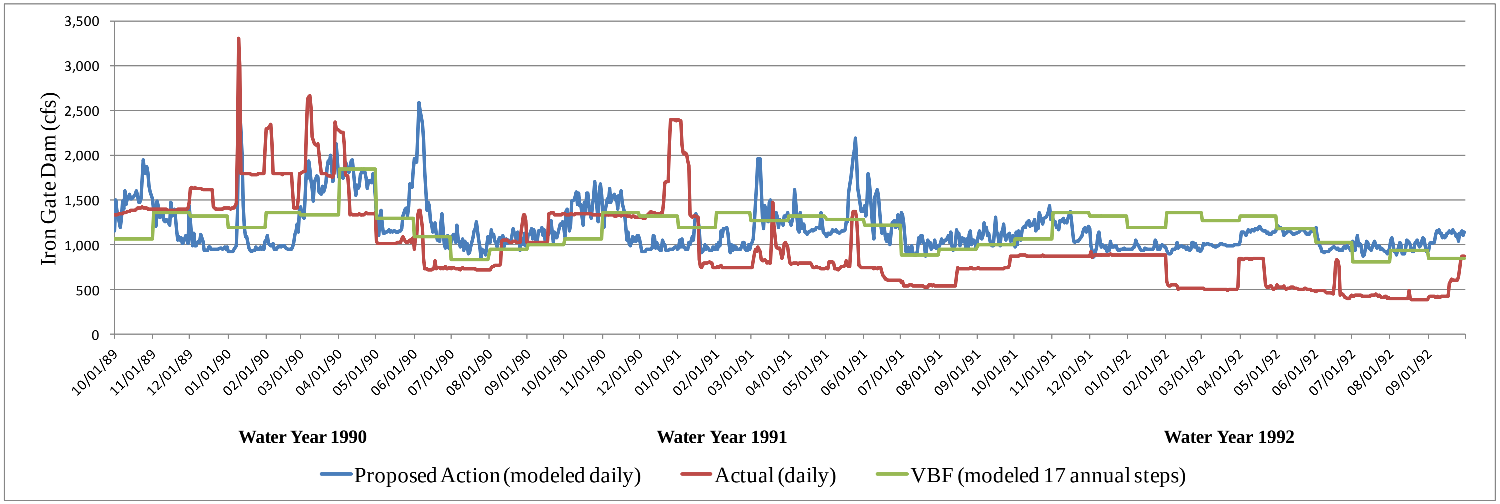
Appendix 8A-1. Iron Gate Dam actual daily average flows during the Period of Record (October 1, 1980 to September 30, 2011), modeled daily average flows with the implementation of the Proposed Action when applied to the Period of Record, and the modeled flows (17 annual steps) with the implementation of the Variable Base Flows (VBF) approach when applied to the Period of Record, by water year.



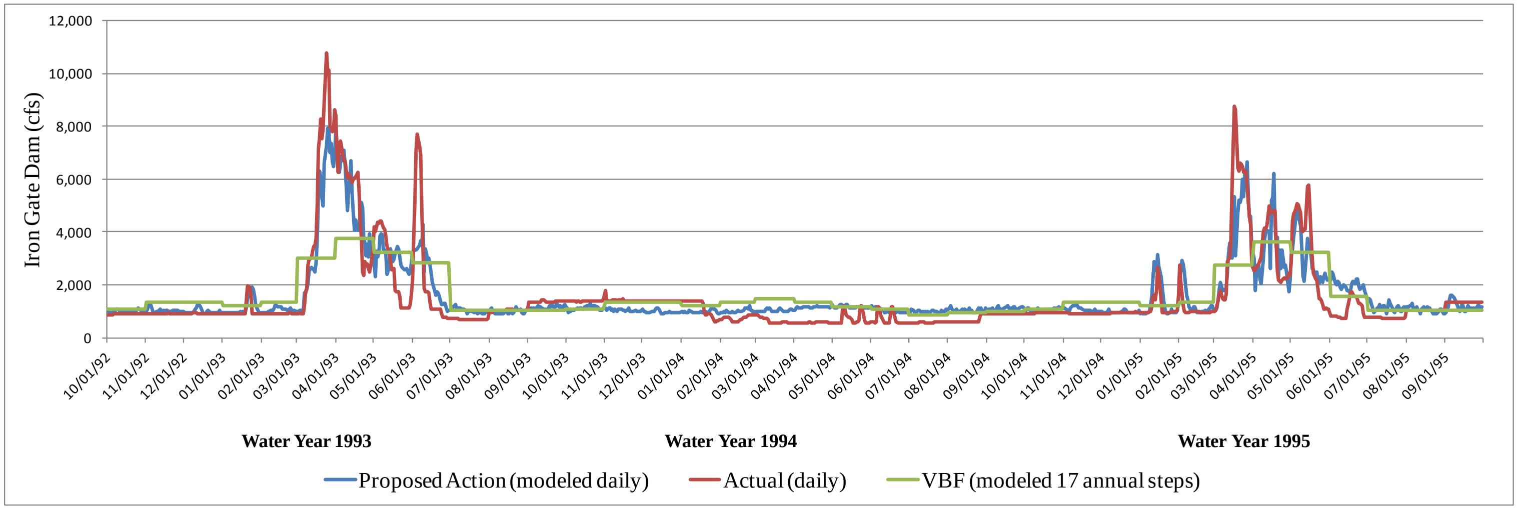


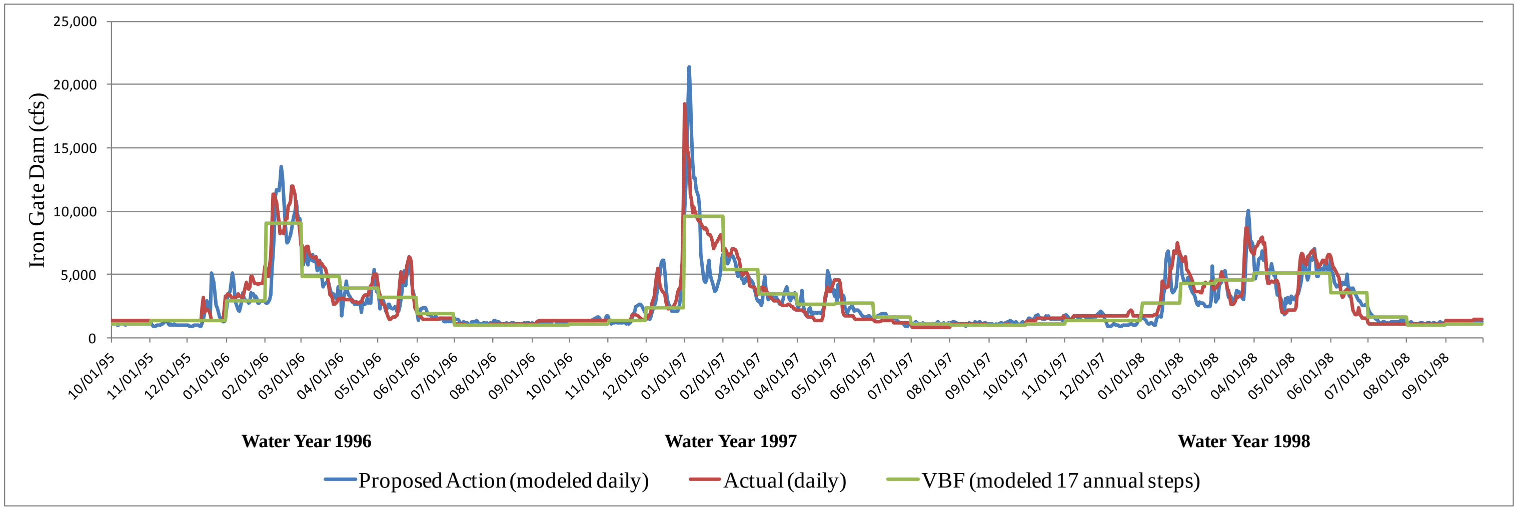
Appendix 8A-1(Continued). Iron Gate Dam actual daily average flows during the Period of Record, modeled daily average flows with the implementation of the Proposed Action when applied to the Period of Record, and the modeled flows (17 annual steps) with the implementation of the Variable Base Flows (VBF) approach when applied to the Period of Record, by water year.



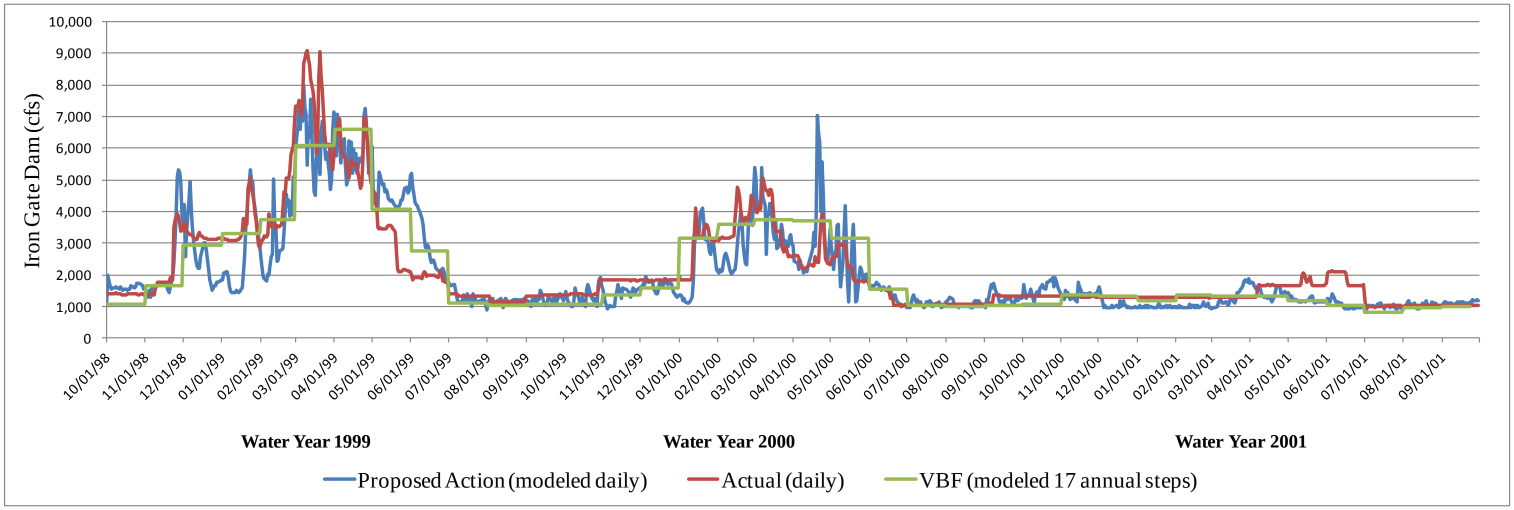


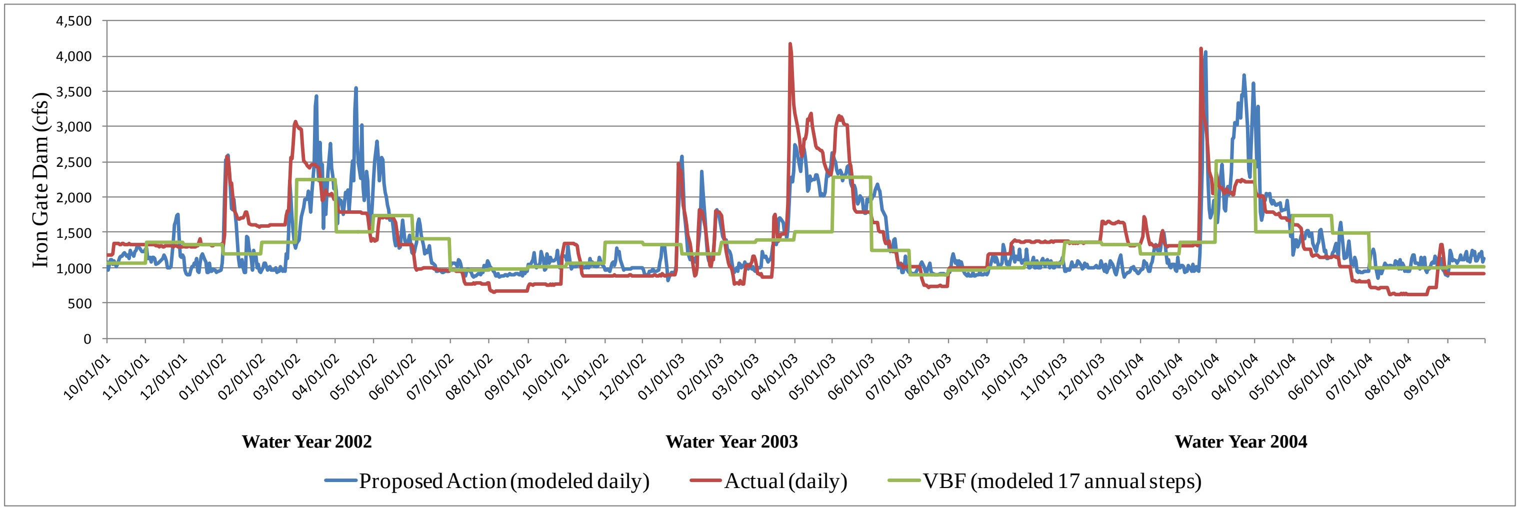
Appendix 8A-1(Continued). Iron Gate Dam actual daily average flows during the Period of Record, modeled daily average flows with the implementation of the Proposed Action when applied to the Period of Record, and the modeled flows (17 annual steps) with the implementation of the Variable Base Flows (VBF) approach when applied to the Period of Record, by water year.



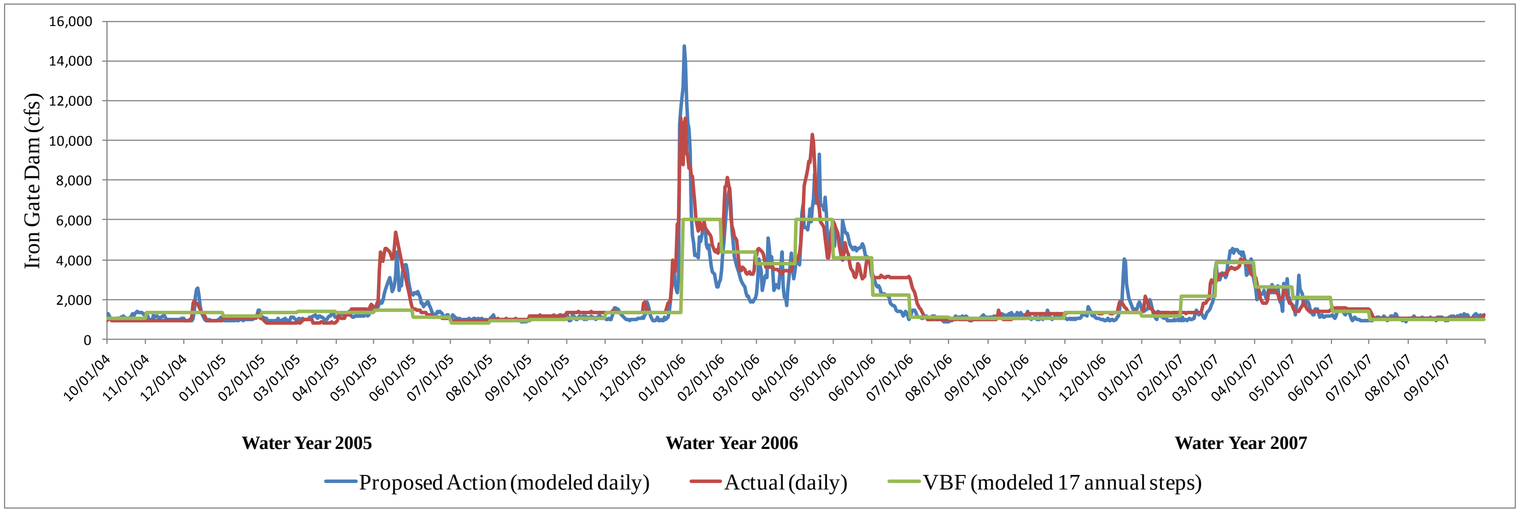


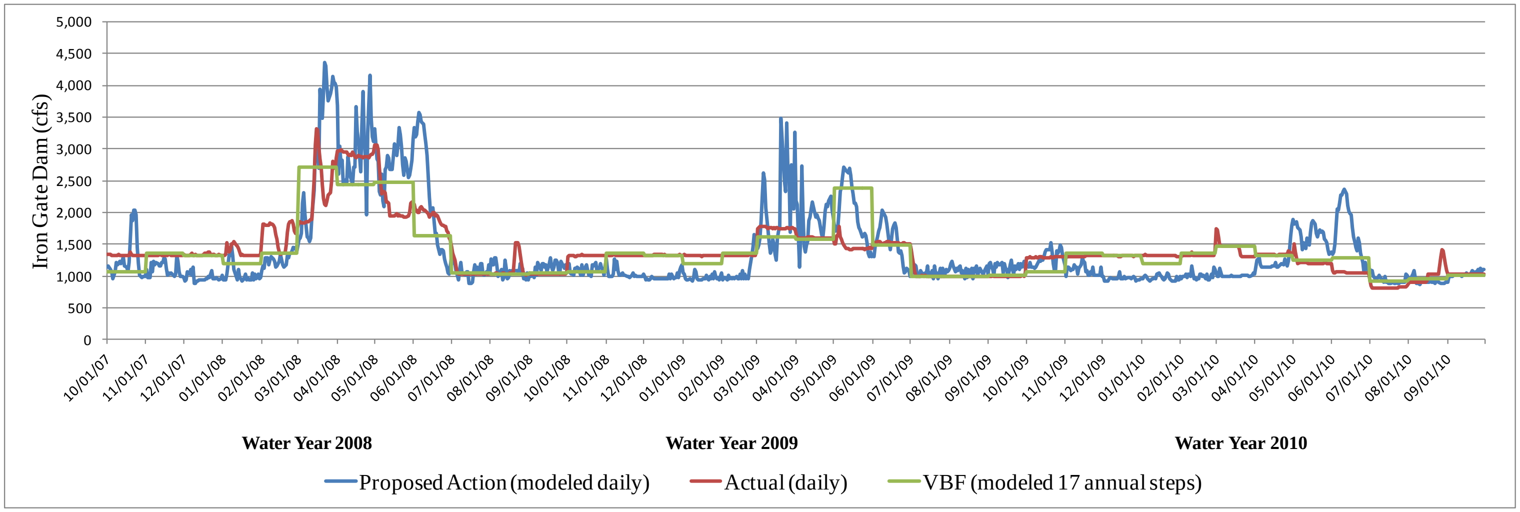
Appendix 8A-1 (Continued). Iron Gate Dam actual daily average flows during the Period of Record, modeled daily average flows with the implementation of the Proposed Action when applied to the Period of Record, and the modeled flows (17 annual steps) with the implementation of the Variable Base Flows (VBF) approach when applied to the Period of Record, by water year.



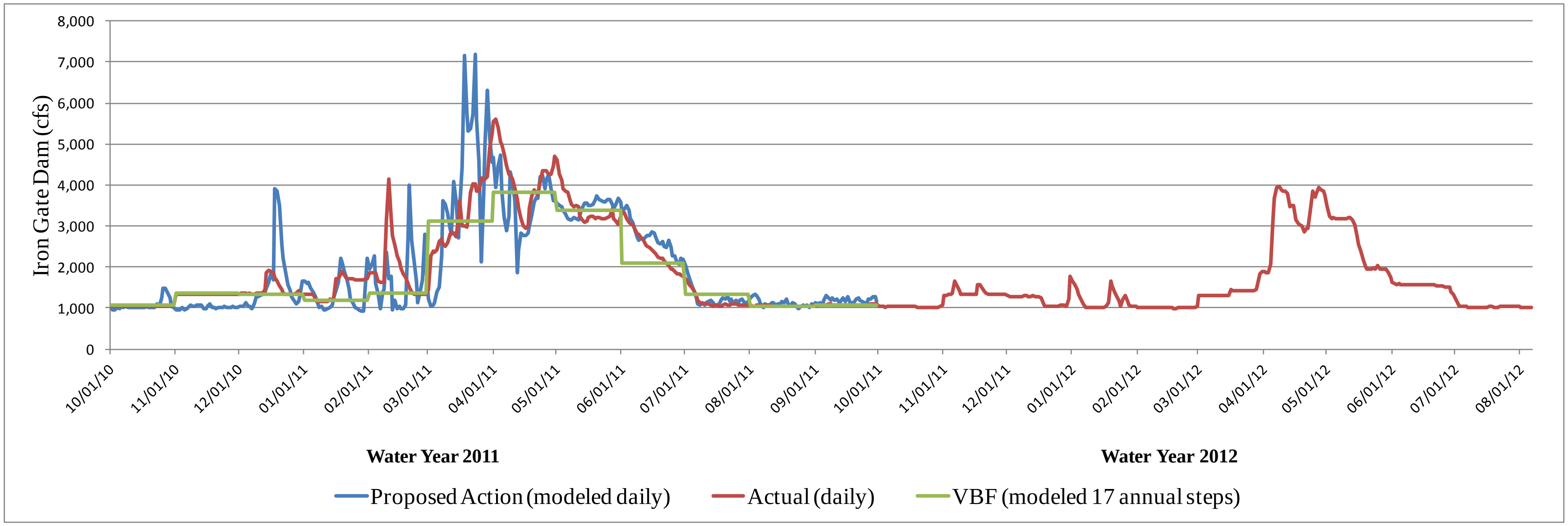


Appendix 8A-1 (Continued). Iron Gate Dam actual daily average flows during the Period of Record, modeled daily average flows with the implementation of the Proposed Action when applied to the Period of Record, and the modeled flows (17 annual steps) with the implementation of the Variable Base Flows (VBF) approach when applied to the Period of Record, by water year.





Appendix 8A-1 (Continued). Iron Gate Dam actual daily average flows during the Period of Record, modeled daily average flows with the implementation of the Proposed Action when applied to the Period of Record, and the modeled flows (17 annual steps) with the implementation of the Variable Base Flows (VBF) approach when applied to the Period of Record, by water year.



Appendix 8A-2. Exceedance table for the historical Iron Gate Dam flows, Period of Record (October 1, 1980 through September 30, 2011). Flows are in cfs.

	January 1-15	January 16-31	February 1-15	February 15-28/29	March 1-15	March 16-31	April 1-15	April 16-30	May 1-15	May 16-31	June 1-15	June 16-30
95%	977	889	713	768	781	701	822	695	751	819	719	657
90%	1224	1072	833	806	915	993	1188	1021	1010	979	741	726
85%	1275	1118	1004	937	1121	1319	1324	1315	1023	1021	763	738
80%	1324	1292	1228	976	1516	1494	1528	1345	1025	1039	793	744
75%	1354	1322	1305	1313	1715	1824	1604	1443	1340	1101	879	747
70%	1385	1325	1323	1335	1953	1958	1742	1598	1519	1201	959	755
65%	1419	1334	1327	1560	2070	2153	1786	1679	1585	1350	1037	815
60%	1428	1344	1353	1638	2115	2219	1863	1715	1730	1422	1070	934
55%	1508	1537	1655	1719	2152	2562	2074	2291	1906	1450	1211	1007
50%	1619	1649	1741	1791	2190	3015	2361	2553	2204	1529	1362	1083
45%	1729	1745	1908	2144	2470	3110	2938	2782	2545	1703	1472	1108
40%	1821	1804	2275	2571	2617	3512	2955	2853	2784	1837	1529	1163
35%	1850	1865	2510	2628	3390	3771	3547	2925	2960	1903	1544	1371
30%	1947	3001	3183	3450	3914	4009	4374	3567	3283	1969	1551	1519
25%	2422	3077	3248	4088	4197	5185	5182	3779	3596	2236	1983	1533
20%	2841	3257	3292	4378	4441	5795	5932	3952	3760	3203	2099	1637
15%	3192	3560	3588	4828	5573	6400	6080	4134	3922	3414	2687	1755
10%	4567	4449	4994	6700	7748	6690	6357	4403	4618	3577	3130	1921
5%	6533	5177	6208	9913	8547	7328	6687	5699	4740	3948	3714	2063

Appendix 8A-2 (Continued). Exceedance table for the historical Iron Gate Dam flows, Period of Record (October 1, 1980 through September 30, 2011). Flows are in cfs.

	July 1-15	July 16-31	August 1-15	August 16-31	September 1-15	September 16-30	October 1-15	October 16-31	November 1-15	November 16-30	December 1-15	December 16-31
95%	559	559	564	680	746	805	887	880	880	892	904	936
90%	611	625	616	737	902	867	924	913	914	916	923	974
85%	710	667	760	910	950	912	981	936	926	1117	1304	1260
80%	721	712	906	985	995	999	1040	1035	1021	1306	1319	1319
75%	731	723	936	993	1025	1023	1253	1167	1309	1314	1327	1324
70%	739	728	994	998	1029	1027	1285	1299	1320	1319	1332	1328
65%	741	731	998	1014	1030	1031	1308	1327	1330	1328	1335	1364
60%	756	734	1007	1018	1034	1039	1323	1329	1330	1331	1365	1413
55%	811	737	1011	1022	1054	1063	1336	1335	1331	1332	1397	1449
50%	831	763	1015	1032	1075	1180	1343	1340	1335	1334	1429	1473
45%	913	792	1025	1034	1183	1308	1346	1342	1341	1340	1443	1588
40%	926	822	1028	1038	1222	1320	1351	1350	1346	1367	1628	1720
35%	1029	892	1030	1043	1302	1340	1357	1362	1355	1398	1637	1834
30%	1050	997	1031	1048	1323	1350	1366	1379	1398	1575	1642	1845
25%	1059	1012	1033	1055	1331	1353	1378	1399	1493	1748	1784	2247
20%	1089	1022	1037	1073	1336	1355	1402	1472	1647	1819	2461	3131
15%	1112	1032	1053	1084	1353	1382	1593	1553	1755	2218	3203	3429
10%	1273	1056	1058	1116	1385	1486	1796	1800	1825	2792	3288	3763
5%	1561	1099	1088	1131	1458	1688	2158	2440	2947	4241	4277	5148

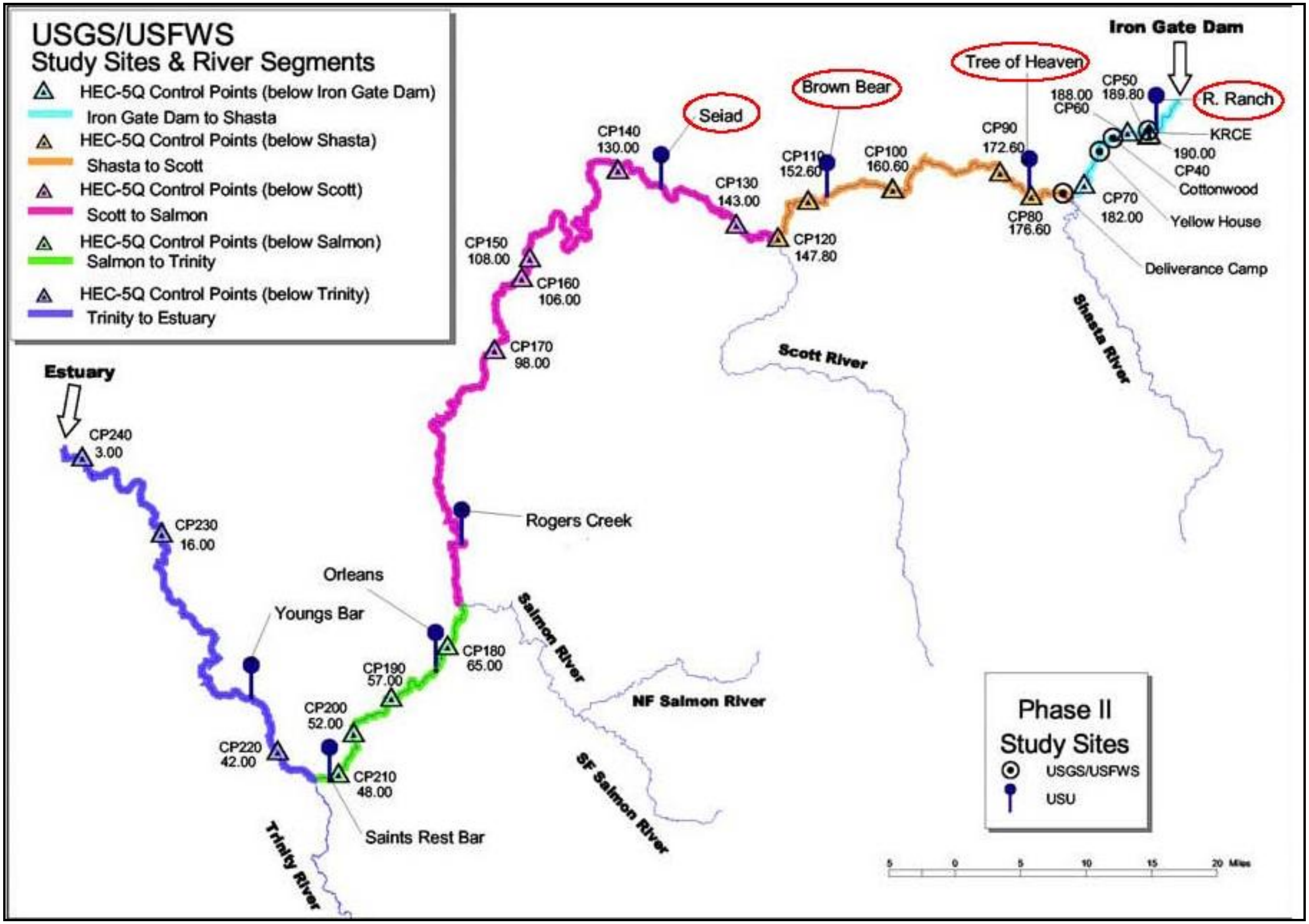
Appendix 8A-3. Exceedance table of modeled Iron Gate Dam flows (in cfs) with the implementation of the Proposed Action. To develop this exceedance table, the Proposed Action was applied to the Period of Record (October 1, 1980 through September 30, 2011). Modeled daily results were then used to generate the exceedance table.

	January 1-15	January 16-31	February 1-15	February 15-28/29	March 1-15	March 16-31	April 1-15	April 16-30	May 1-15	May 16-31	June 1-15	June 16-30
95%	951	971	962	986	1021	1020	1157	1173	1172	1146	1094	953
90%	961	971	971	1009	1056	1133	1206	1236	1193	1162	1156	968
85%	972	981	980	1013	1093	1405	1246	1335	1313	1202	1281	974
80%	976	988	982	1040	1395	1734	1512	1610	1415	1243	1322	986
75%	1010	1013	990	1058	1701	1769	1687	1684	1549	1332	1383	1094
70%	1048	1029	998	1064	1749	1806	1841	1751	1640	1402	1619	1119
65%	1086	1079	1051	1260	1948	2376	2008	1878	2019	1628	1670	1186
60%	1100	1107	1053	1365	1980	2994	2155	2229	2213	1714	1692	1213
55%	1271	1137	1144	1538	2118	3156	2321	2285	2294	1884	1853	1220
50%	1385	1281	1211	1935	2270	3210	2349	2792	2379	1976	1861	1241
45%	1440	1361	1495	2082	2551	3555	2588	3167	2501	2045	1929	1260
40%	1489	1477	1680	2293	3000	3807	3069	3232	2654	2406	1973	1374
35%	1619	1568	1841	2333	3323	3945	3324	3265	2783	2693	1991	1402
30%	1664	2129	2218	2599	3632	4516	3707	3648	3164	2903	2047	1410
25%	1757	2951	2442	3267	3991	5078	5179	3945	3321	3281	2311	1465
20%	2287	3093	2765	3906	4467	5487	5232	4122	3586	3584	2979	1598
15%	2677	3310	3475	4351	5461	5798	5604	4326	4127	4107	3139	2048
10%	3231	3548	4046	6870	6162	6169	5942	4675	4320	4413	3695	2360
5%	6562	4356	5425	9446	7012	6861	6157	5815	4827	4777	4167	2602

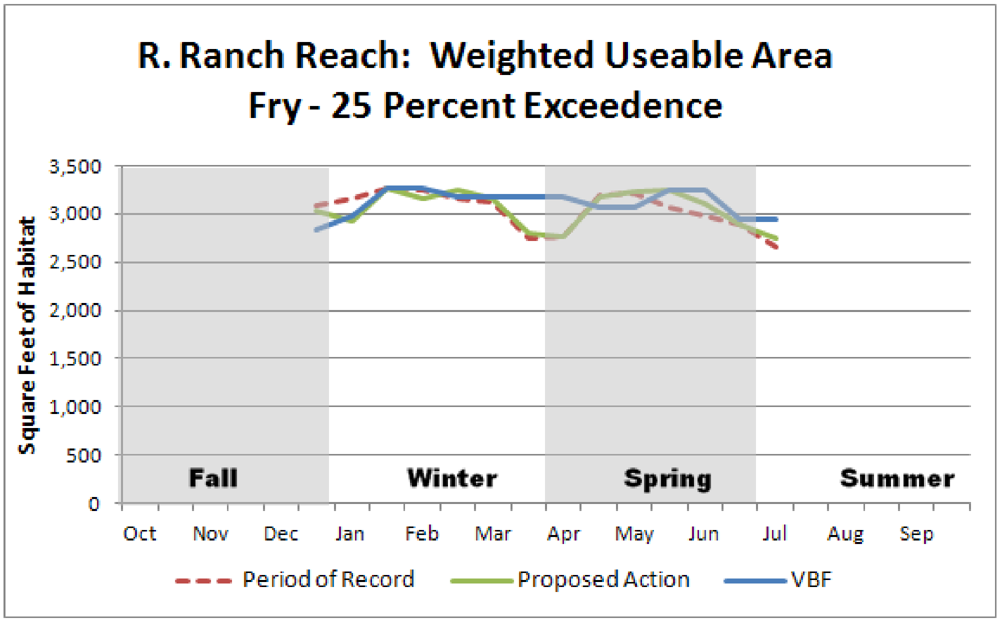
Appendix 8A-3 (Continued). Exceedance table of modeled Iron Gate Dam flows (in cfs) with the implementation of the Proposed Action. To develop this exceedance table, the Proposed Action was applied to the Period of Record. Modeled daily results were then used to generate the exceedance table.

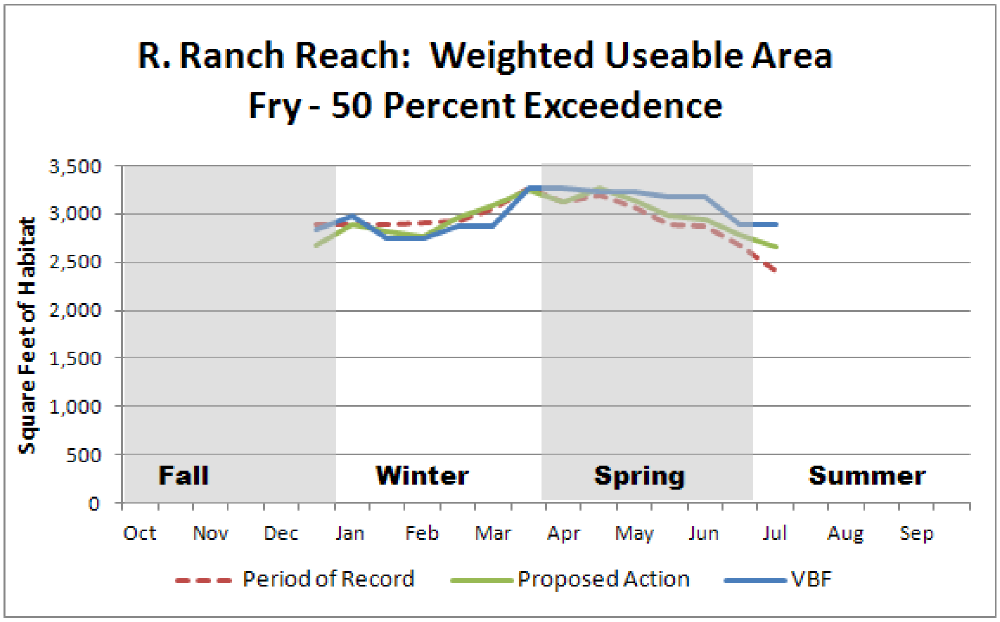
July 1-15	July 16-31	August 1-15	August 16-31	September 1-15	September 16-30	October 1-15	October 16-31	November 1-15	November 16-30	December 1-15	December 16-31
983	925	943	908	1074	1108	1025	1049	1027	1007	959	956
988	943	974	932	1079	1122	1033	1058	1053	1014	963	961
998	959	980	973	1082	1127	1044	1090	1063	1015	974	964
1018	985	1021	994	1095	1127	1054	1106	1067	1015	996	965
1027	995	1024	1004	1100	1139	1061	1141	1077	1016	1006	974
1034	1006	1027	1015	1101	1145	1066	1172	1082	1023	1011	979
1035	1019	1047	1026	1105	1149	1080	1182	1110	1040	1025	989
1051	1023	1056	1030	1109	1151	1103	1195	1132	1068	1043	1003
1060	1024	1058	1037	1111	1159	1116	1206	1143	1100	1092	1015
1077	1047	1065	1043	1115	1164	1143	1221	1156	1153	1122	1086
1090	1050	1073	1049	1120	1171	1154	1259	1184	1188	1144	1290
1100	1052	1100	1052	1150	1176	1193	1325	1222	1286	1176	1507
1139	1066	1107	1064	1161	1184	1226	1372	1229	1376	1199	1560
1170	1080	1110	1068	1176	1215	1234	1405	1263	1423	1441	2009
1201	1102	1117	1085	1182	1217	1288	1478	1338	1471	1637	2128
1237	1167	1139	1103	1196	1219	1332	1493	1393	1487	1888	2398
1294	1169	1152	1133	1233	1242	1396	1584	1469	1852	2028	2814
1374	1199	1161	1156	1254	1258	1424	1652	1528	2669	3209	3163
1439	1252	1169	1169	1302	1285	1546	1705	1584	2952	3456	5381

Appendix 8A-4. Hardy and Addley (2006) river reach delineations and study site locations within the main stem Klamath River. R. Ranch, Trees of Heaven, Brown Bear, and Seiad study sites are highlighted. *Source: Figure 16, p. 54, Hardy and Addley 2006.*

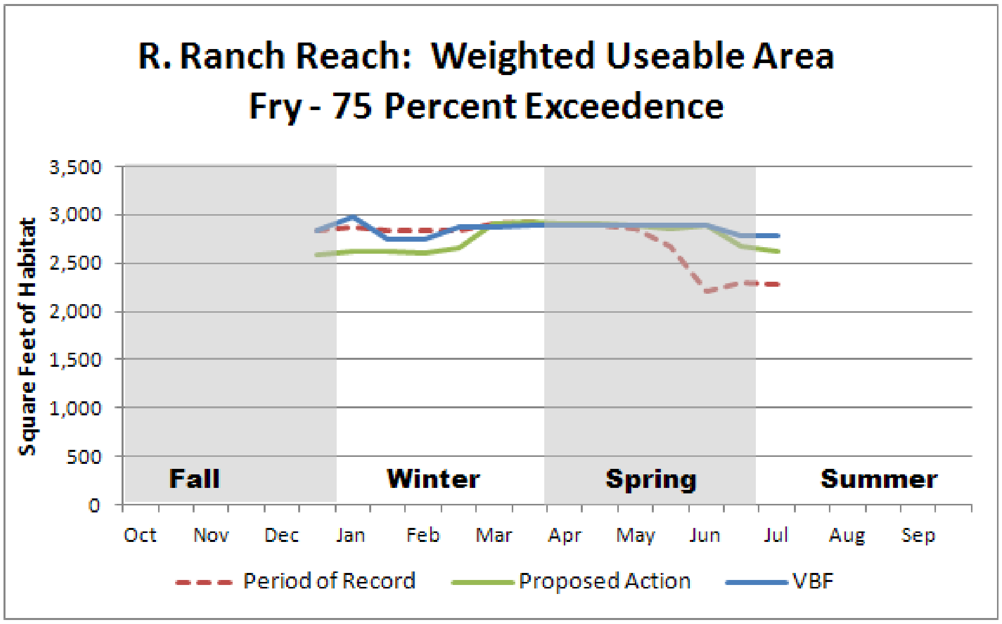


Appendix 8A-5. Square feet of coho salmon fry habitat at the 75 percent, 50 percent, and 25 percent exceedance level for the Period of Record (October 1, 1980 to September 31, 2011), for the Proposed Action applied to the Period of Record, and for the Variable Base Flow (VBF) approach applied to the Period of Record, R. Ranch Reach. The fry life stage is typically present during the winter and spring period, as depicted in these figures. *Flow-Habitat Relationship Source: Appendix I, Hardy et al. 2006.*

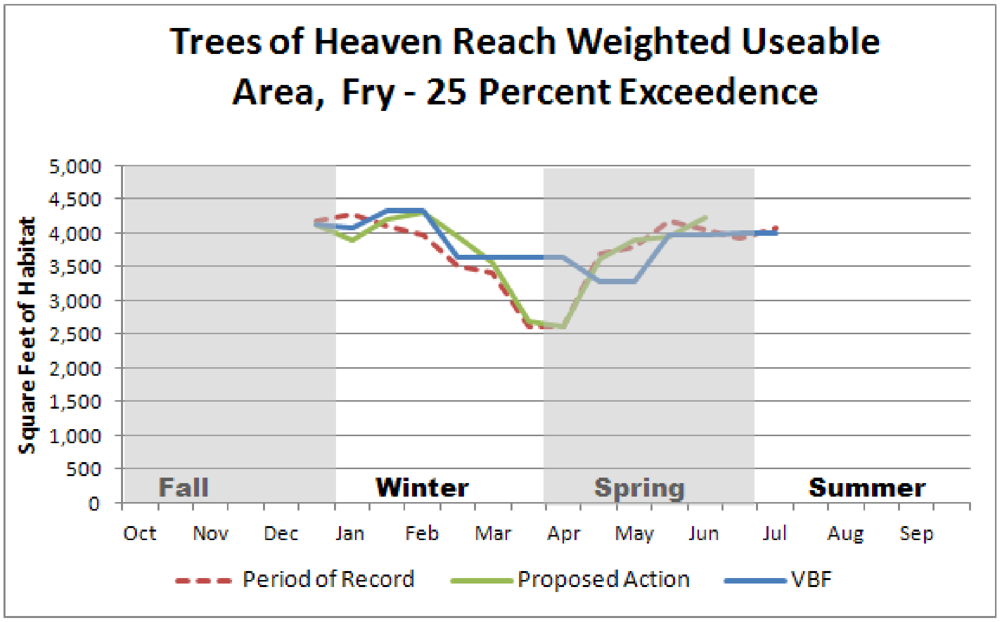


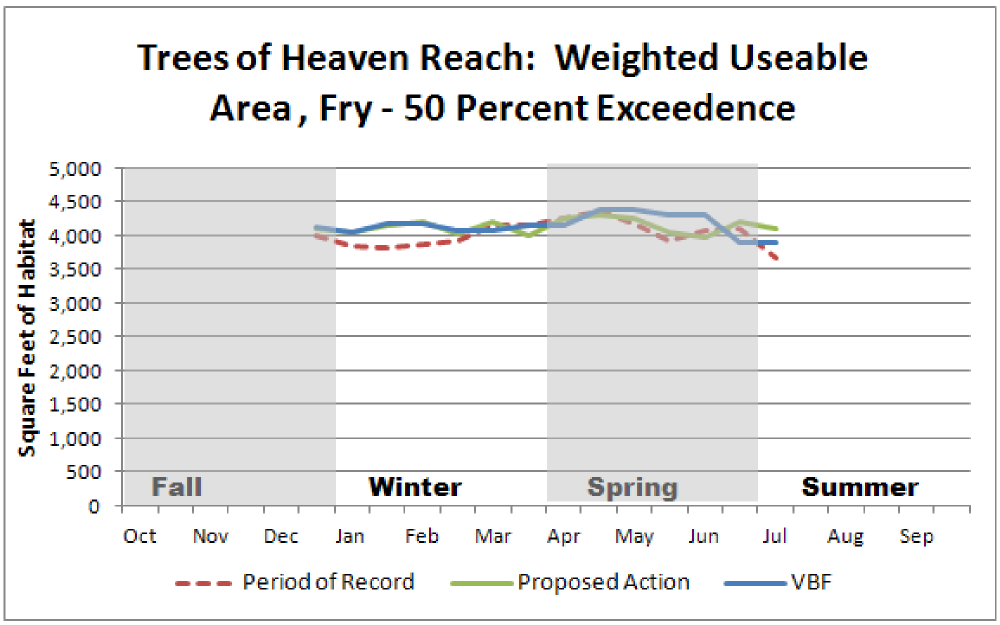


Appendix 8A-5 (Continued). Square feet of coho salmon fry habitat at the 75 percent, 50 percent, and 25 percent exceedance level for the Period of Record (October 1, 1980 to September 31, 2011), for the Proposed Action applied to the Period of Record, and for the Variable Base Flow (VBF) approach applied to the Period of Record, R. Ranch Reach. The fry life stage is typically present during the winter and spring period, as depicted in these figures. *Flow-Habitat Relationship Source: Appendix I, Hardy et al. 2006.*

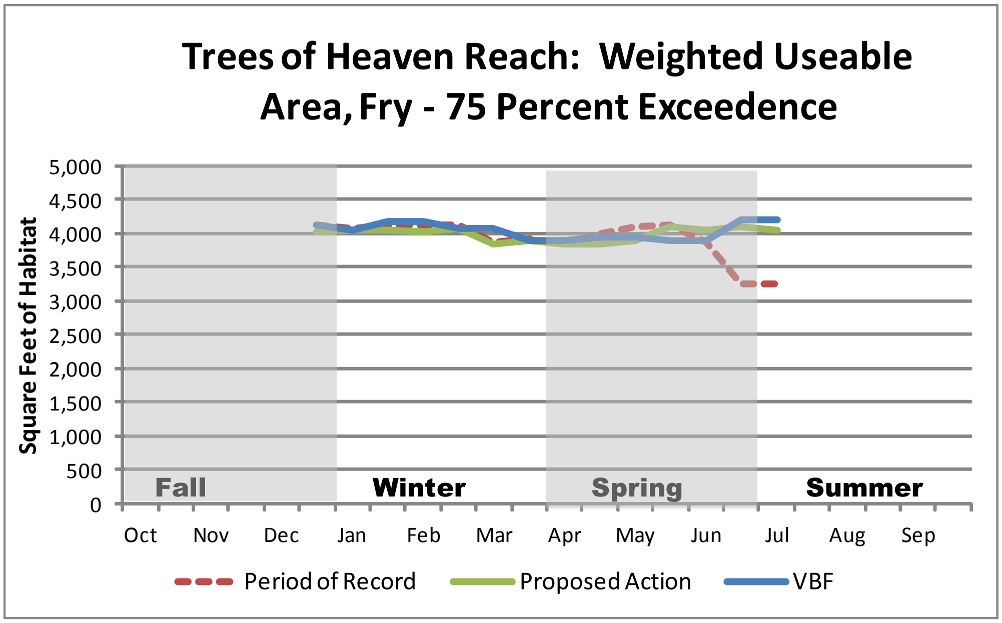


Appendix 8A-6. Square feet of coho salmon fry habitat at the 75 percent, 50 percent, and 25 percent exceedance level for the Period of Record (actual; October 1, 1980 to September 31, 2011), for the Proposed Action applied to the Period of Record, and for the Variable Base Flow (VBF) procedure applied to the Period of Record,, Trees of Heaven Reach. The fry life stage is typically present during the winter and spring. *Flow-Habitat Relationship Source: Appendix I, Hardy et al. 2006.*

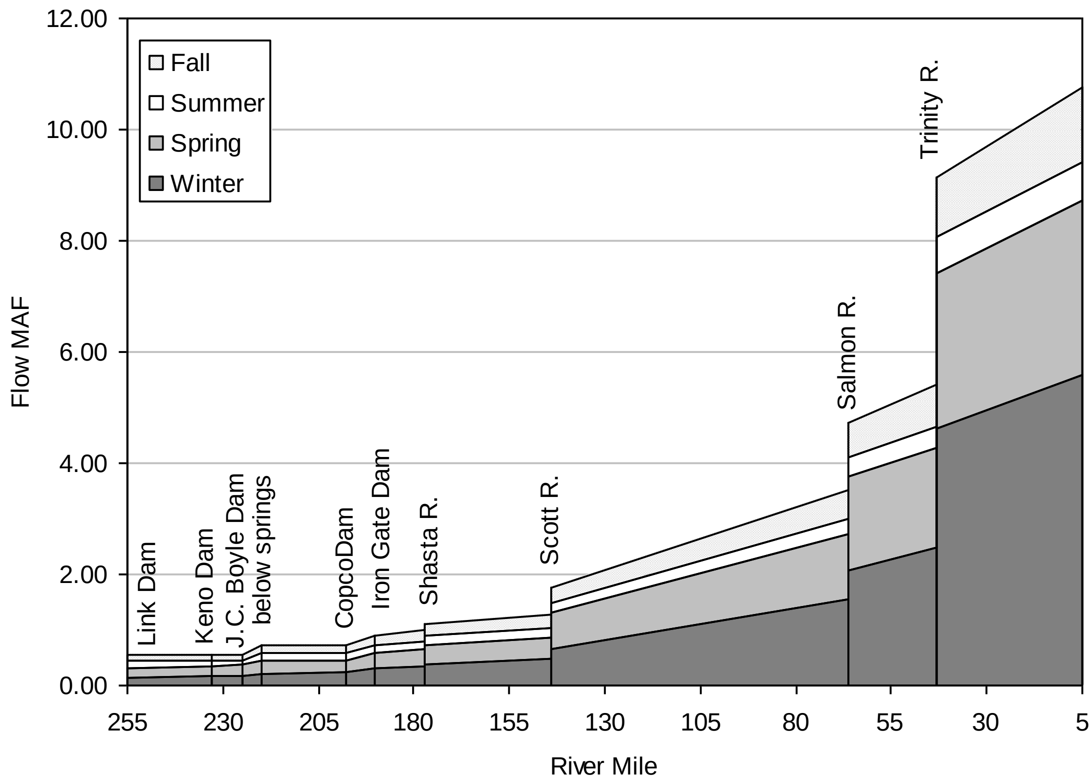




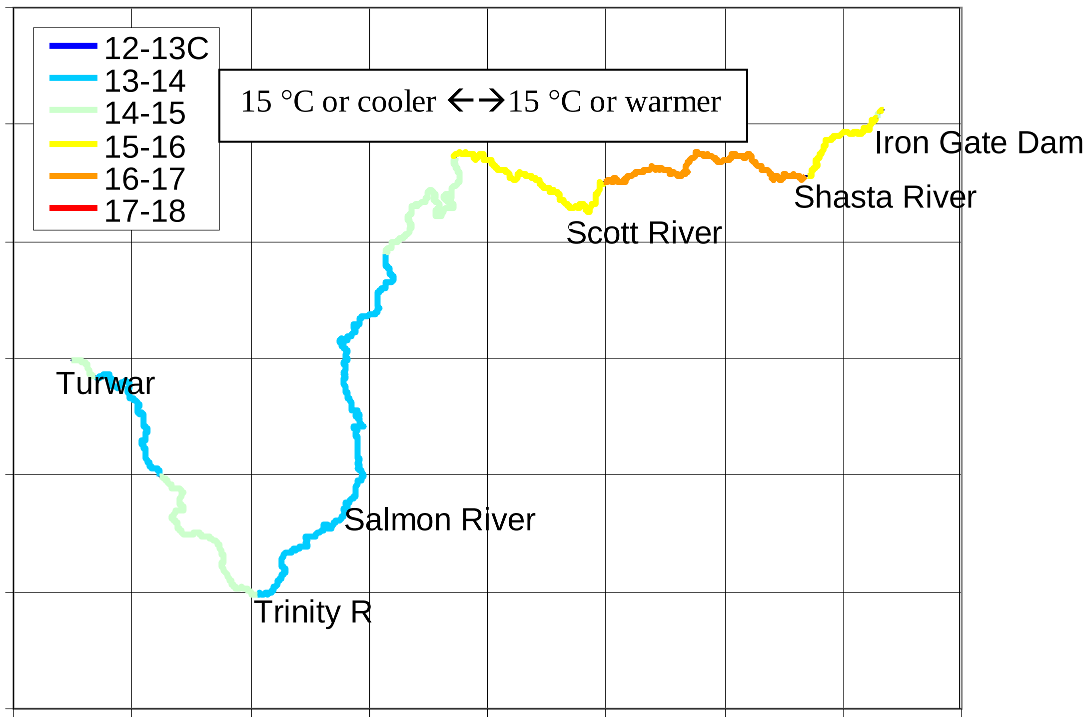
Appendix 8A-6 (Continued). Square feet of coho salmon fry habitat at the 75 percent, 50 percent, and 25 percent exceedance level for the Period of Record (actual; October 1, 1980 to September 31, 2011), for the Proposed Action applied to the Period of Record, and for the Variable Base Flow (VBF) procedure applied to the Period of Record, Trees of Heaven Reach. The fry life stage is typically present during the winter and spring. *Flow-Habitat Relationship Source: Appendix I, Hardy et al. 2006.*



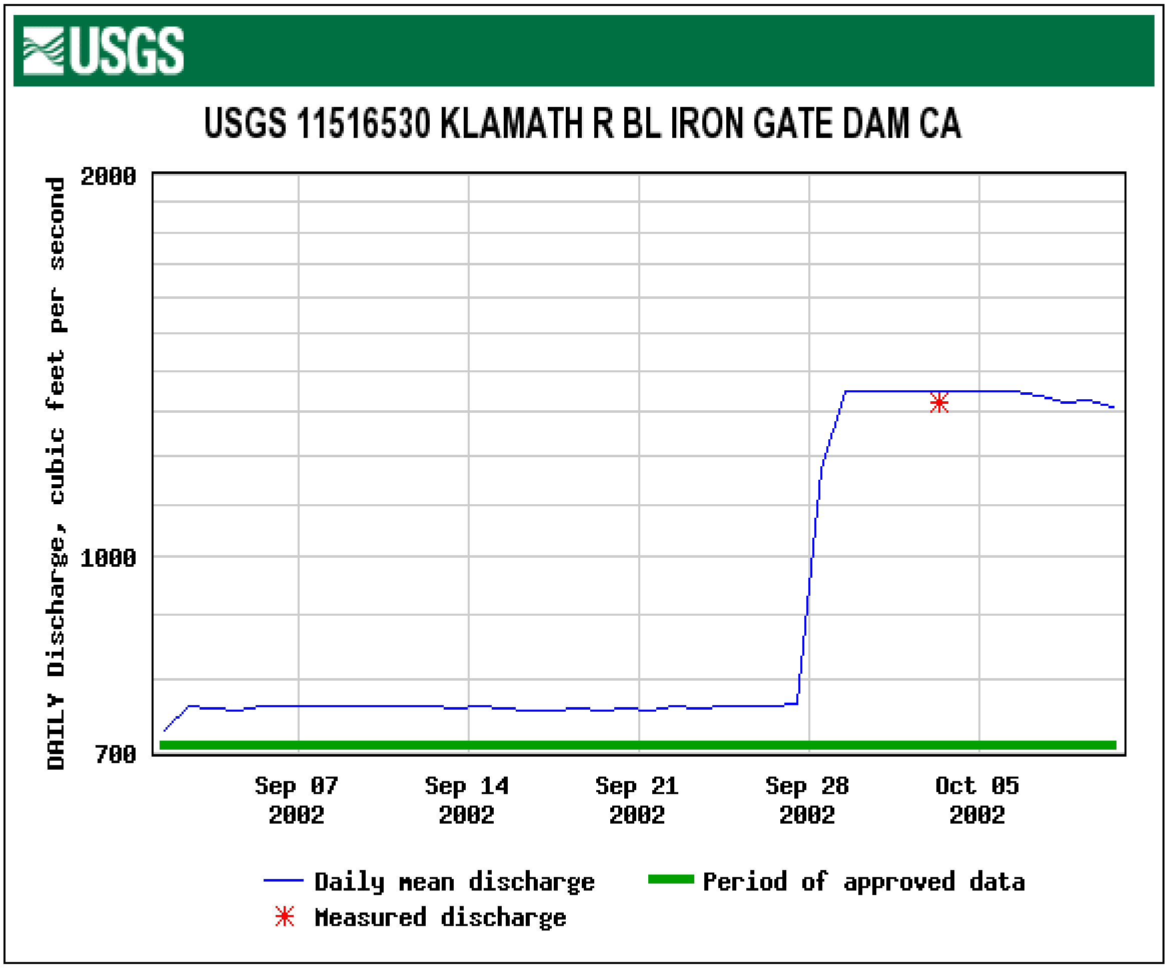
Appendix 8A-7. Simulated seasonal flows in the Klamath River from Link River to Turwar Creek in 2000. Flows from IGD comprise a progressively smaller proportion of the average annual and seasonal main stem flows at points further downriver. Source: Modified Figure 14, page 88 of Basdekas L. and M. Deas. 2007.



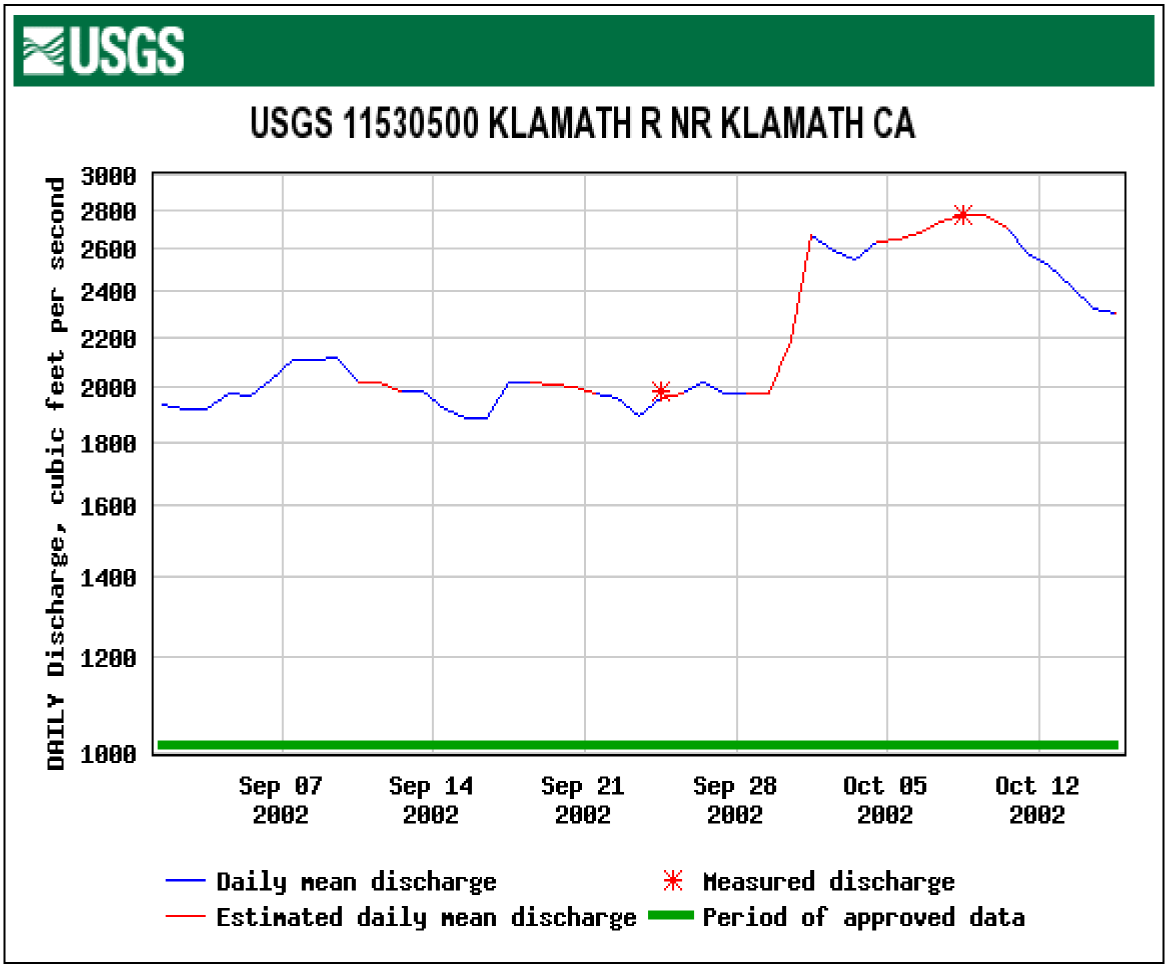
Appendix 8A-8. Longitudinal view of daily mean water temperatures from Iron Gate Dam to Turwar, on June 1 in a typical year. Note that the warmest reach of the Klamath River is between Scott River and Shasta River. Source: Figure 6 on page 11 of Basdekas and Deas 2007.



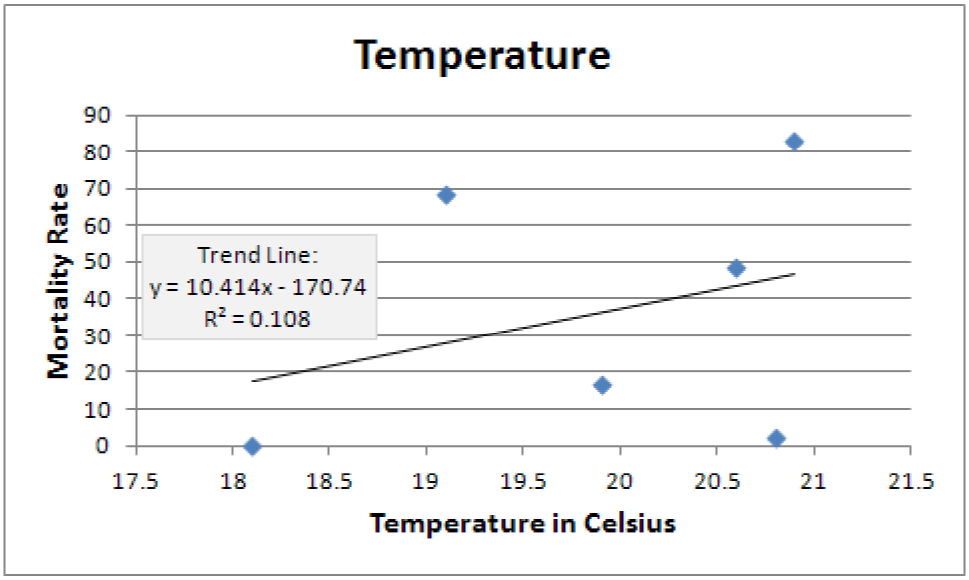
Appendix 8A-9. Klamath River flows immediately downstream of Iron Gate Dam, September 1, through October 10, 2002, as measured at USGS gauge 11516530. On September 19, 2002, reports of dead and dying fish in the Lower Klamath River were received by the Yurok Tribal Fisheries Program and other fisheries agencies. Flows were approximately 760 cfs prior to the increased release on September 28, 2002. Following an additional release of approximately 590 cfs, flows were approximately 1,350 cfs.

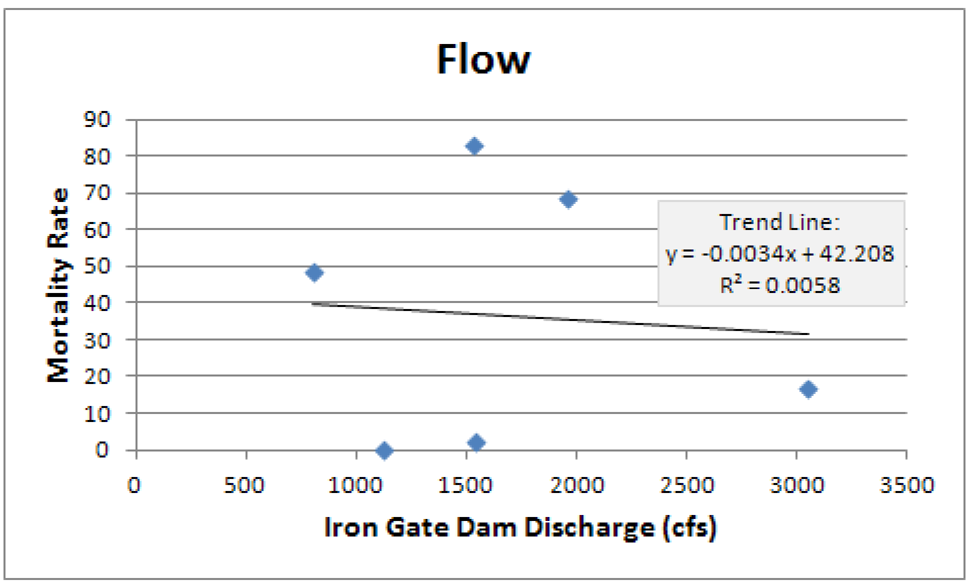


Appendix 8A-10. Klamath River flows near Klamath, California, September 1, through October 10, 2002, as measured at USGS gauge 11530500. On September 19, 2002, reports of dead and dying fish in the Lower Klamath River were received by the Yurok Tribal Fisheries Program and other fisheries agencies. The additional release of 590 cfs at Iron Gate Dam on September 28, 2002 did not reach the USGS gauge 11530500 until October 1, 2002, approximately 3 days later.

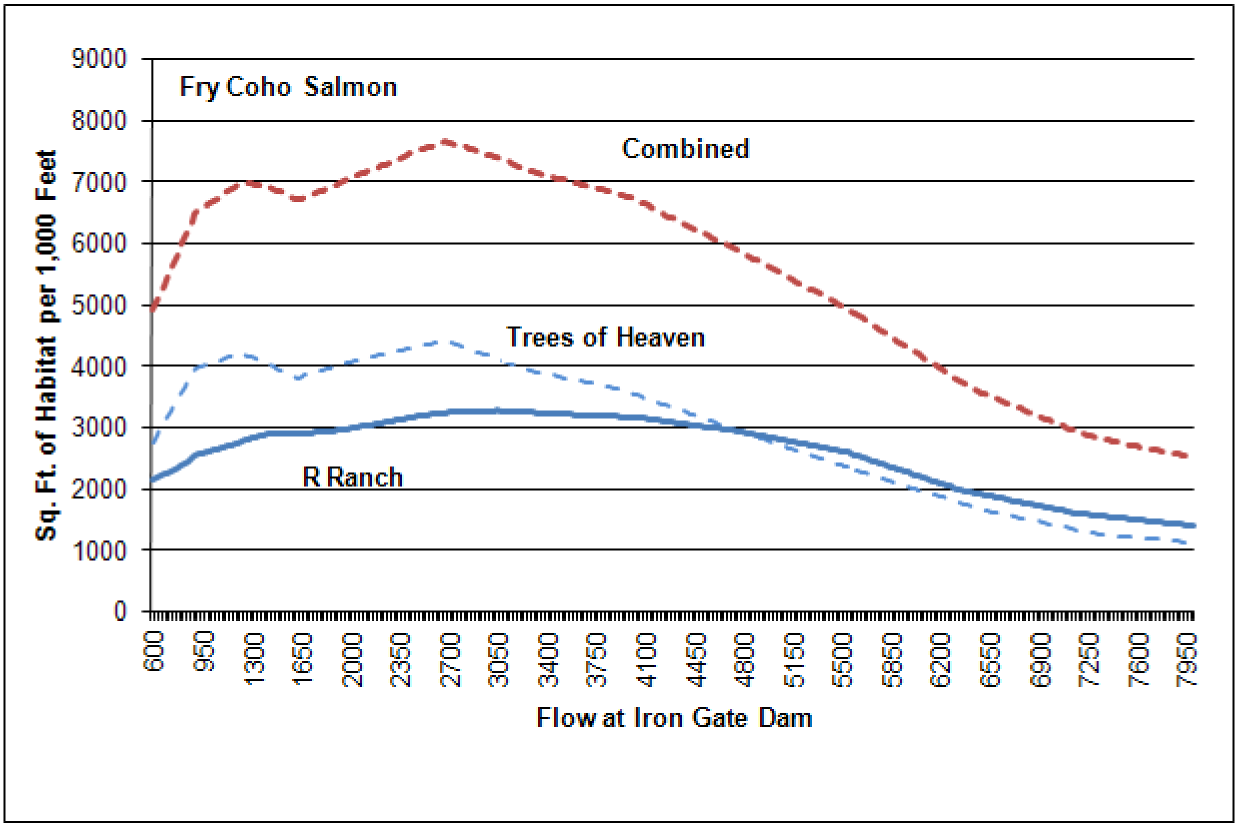


Appendix 8A-11. A scatter plot with a trend line (linear regression) of the average temperature (horizontal axis; top graph) and flow (horizontal axis; bottom graph) and percent mortality (vertical axis) during exposure of Chinook salmon above Beaver Creek during June 2006 to 2009. *Source: Table 5.1 on page 30 of Bartholomew and Foott 2010.*

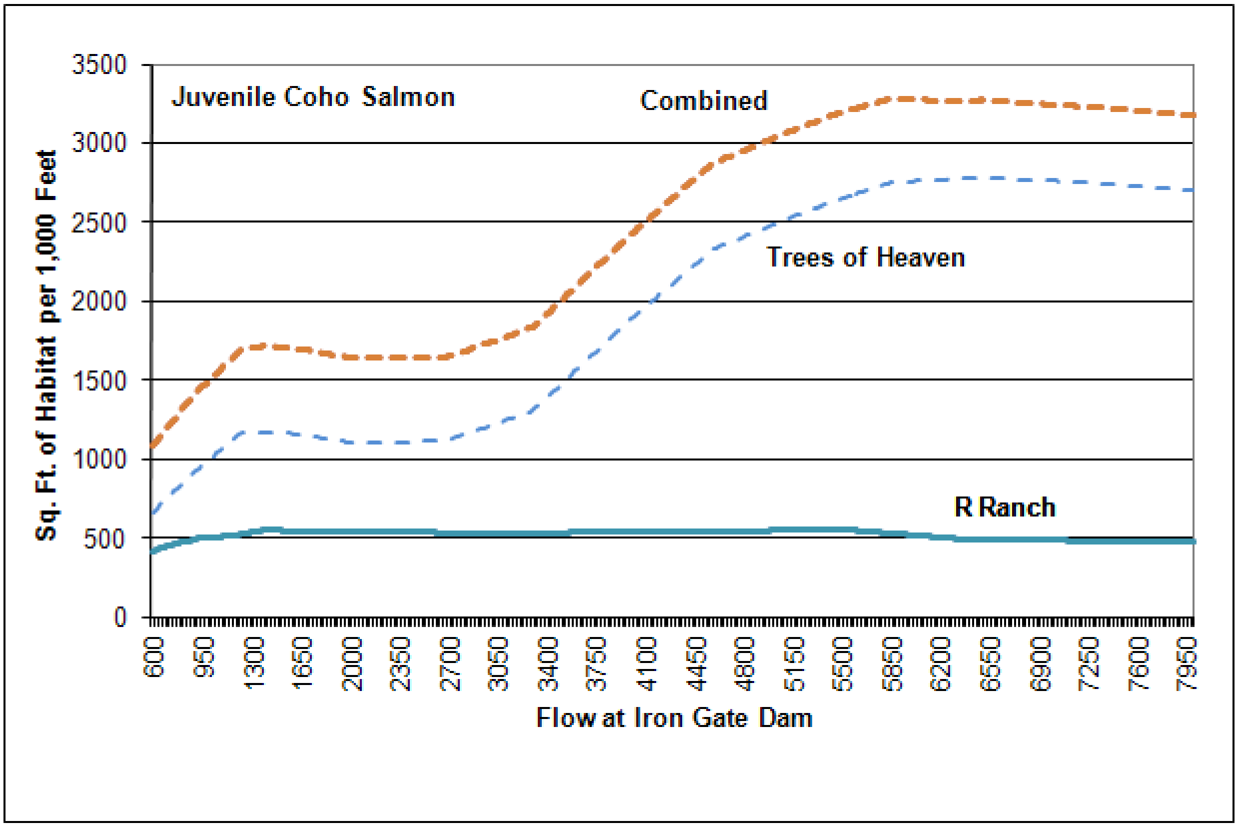




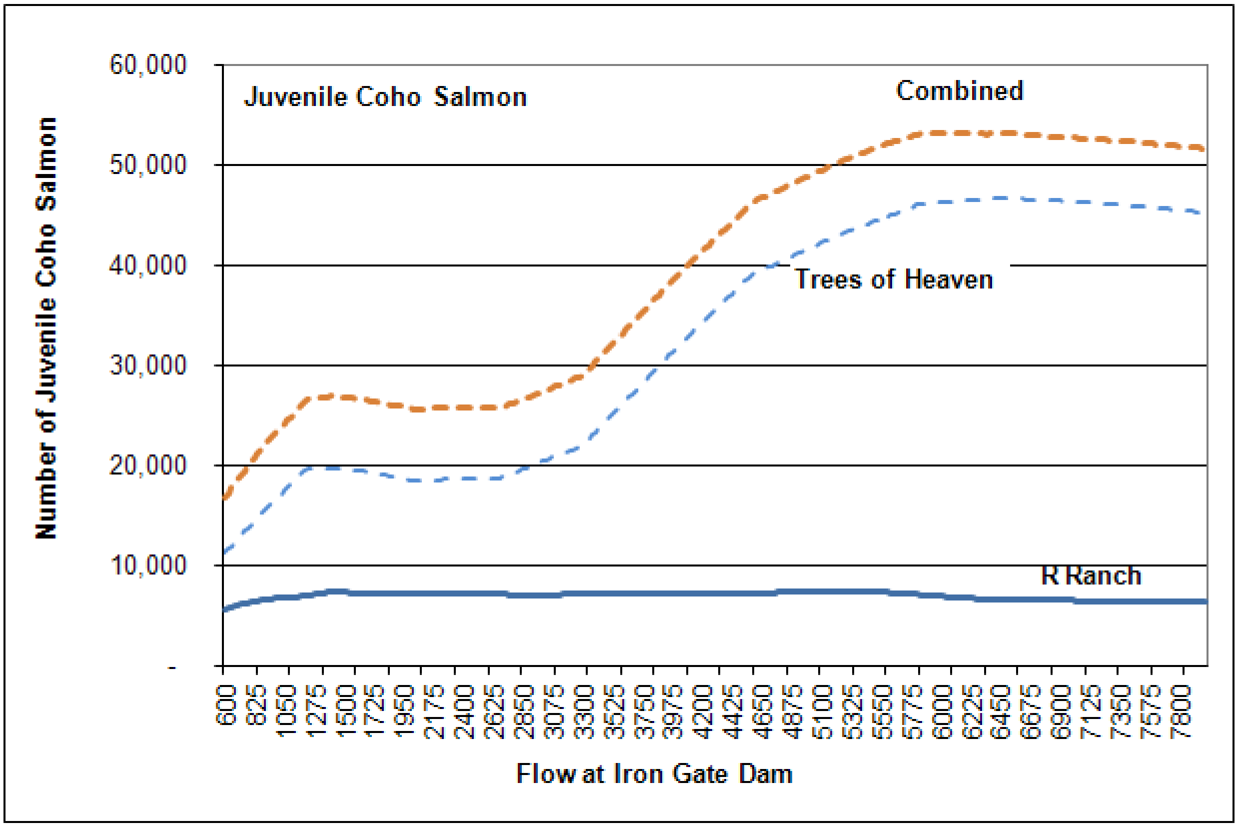
Appendix 8A-12. Square feet of available habitat for coho salmon fry per 1,000 feet of the Klamath River for R. Ranch and Trees of Heaven Reaches, at given Iron Gate Dam releases. *Source: Hardy et al. 2006. Note: Fry are non-territorial, thus less density dependent.*



Appendix 8A-13. Square feet of available habitat for coho salmon juveniles per 1,000 feet of the Klamath River for the R. Ranch and Trees of Heaven Reaches, at given flows. For this analysis, Iron Gate Dam releases were applied directly to the Trees of Heaven Reach. No accretion (e.g., Shasta River) was assumed. *Source: Flow-habitat relationship was provided by Hardy et al. 2006.*

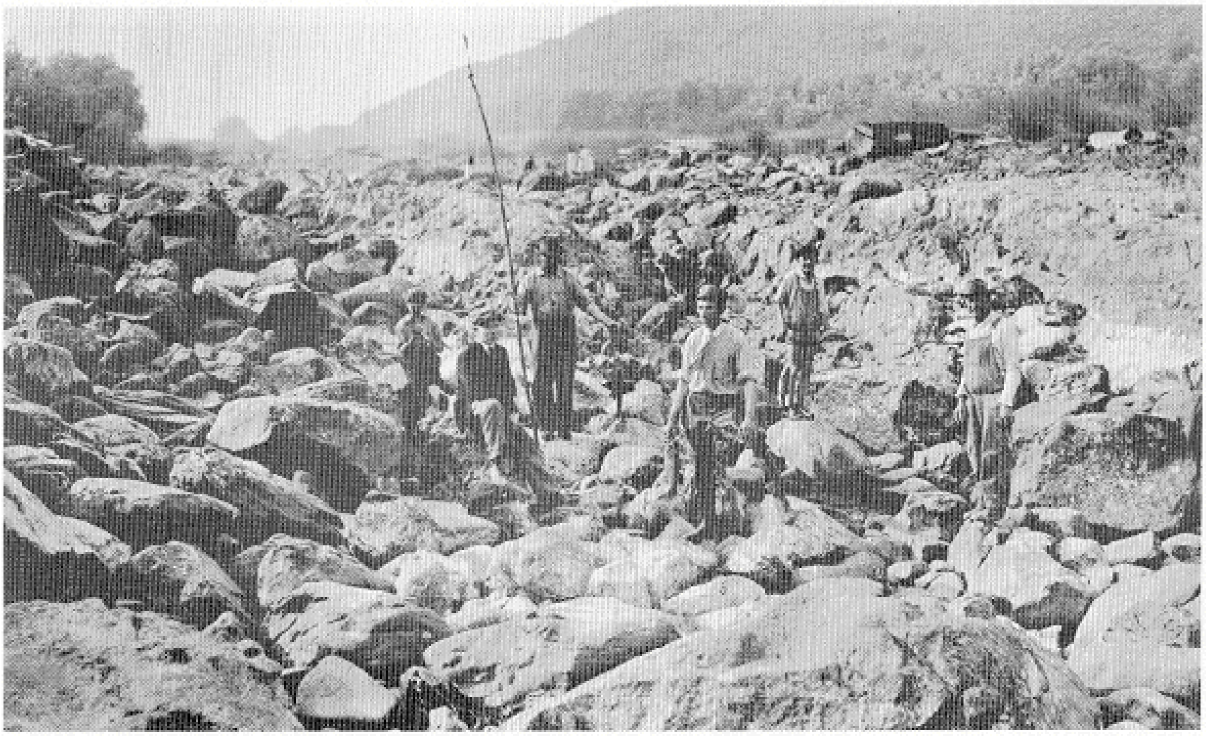


Appendix 8A-14. Estimated number of juvenile coho salmon potential based on available habitat for the R. Ranch and Trees of Heaven Reaches, at given flows. For this analysis, Iron Gate Dam releases were applied directly to the Trees of Heaven Reach. No accretion (e.g., Shasta River) was assumed.



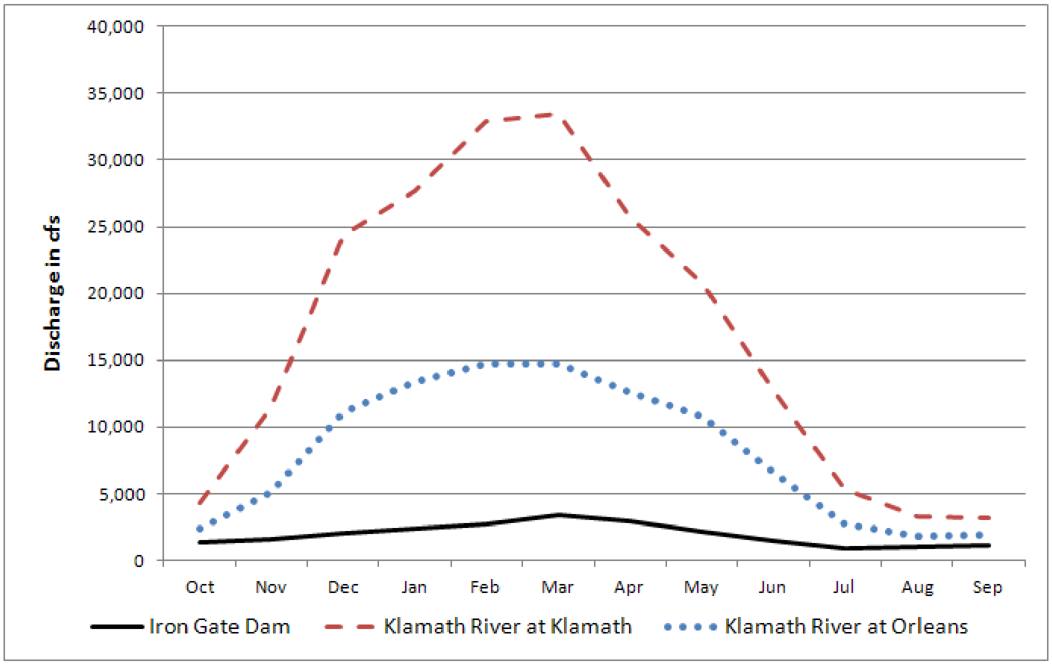
Appendix 8A-15. Picture of a "dry" Link River on July 18, 1918 (Klamath County Museum).

July 18, 1918.



Link River Dry.

Appendix 8A-16. Mean of monthly discharges at three locations on the Klamath River: immediately downstream of Iron Gate Dam (USGS gauge 11516530, RM 190.5); at Orleans (USGS gauge 11523000: RM 57.6); and at Klamath (USGS gauge 11530500, RM 5.3), from October 1980 through September 30, 2011. For the USGS gauge on the Klamath River near Klamath (USGS gauge 11530500), several mean monthly values between 1994 and 1997 were not available.



End of Appendix 8A

Appendix 9A: Other Species

9A.1. Southern DPS North American Green Sturgeon

9A.1.1. Description

Green sturgeon (*Acipenser medirostris)* are long-lived, slow-growing fish and the most marine-oriented of the sturgeon species. Males at maturity range from 4.5 to 6.5 feet (1.4 to 2 m) in fork length and are at least 15 years old (VanEenennaam 2002), while mature females range from 5 to 7 feet (1.6 to 2.2 m) fork length and are at least 17 years old. Adult green sturgeon maximum ages likely range from 60 to 70 years (Moyle 2002). This species is found along the west coast of Mexico, the United States, and Canada.

Green sturgeon are members of the class of bony fishes, and the skeleton is composed mostly of cartilage. Sturgeon lack scales; however, they have five rows of characteristic bony plates on their body called scutes. The green sturgeon backbone curves upward into the caudal fin, forming their shark-like tail. On the ventral, or underside, of their flattened snouts are sensory barbels and a siphon-shaped, protrusible, toothless mouth. Recent genetic information suggests that green sturgeon in North America are taxonomically distinct from morphologically similar forms in Asia.

9A.1.2. Life History

Green sturgeon are believed to spend the majority of their lives in nearshore oceanic waters, bays, and estuaries. Early life-history stages reside in fresh water, with adults returning to freshwater to spawn when they are more than 15 years of age and more than 4 feet (1.3 m) in size. Spawning is believed to occur every 2-5 years (Moyle, 2002). Adults typically migrate into fresh water beginning in late February; spawning occurs from March-July, with peak activity from April-June (Moyle et al., 1995). Females produce 60,000-140,000 eggs (Moyle et al., 1992). Juvenile green sturgeon spend 1-4 years in fresh and estuarine waters before dispersal to saltwater (Beamsesderfer and Webb, 2002). They disperse widely in the ocean after their out-migration from freshwater (Moyle et al., 1992).

Spawning: Green sturgeon spawn every three to five years (Tracy 1990). Their spawning period is March to July, with a peak in mid-April to mid-June (Moyle et al. 1992). Green sturgeon's preferred spawning areas are associated with deep pools or "holes" in large, turbulent river mainstems (Moyle et al. 1992). Spawning habitat preferences are likely large cobble substrates, but may range from clean sand to bedrock substrates. Green sturgeon broadcast their eggs over the large cobble substrates where they settle into the interstitial spaces between cobbles. Green sturgeon females produce 60,000 to 140,000 eggs (Moyle et al. 1992) and they are the largest eggs (diameter 4.34 mm) of any sturgeon species (Cech et al. 2000). Temperatures above 20° C are lethal to green sturgeon embryos (Cech et al. 2000).

Green sturgeon spawning has only been documented in the Klamath, Sacramento (Moyle et al. 1992, CDFG 2002) and Rogue (Erickson et al. 2001, Rien et al. 2001) rivers in recent times. The Klamath Basin is thought to support the largest green sturgeon spawning population (Moyle et al. 1992). In the Klamath River, sturgeon courtship behaviors such as breaching have been observed in "The Sturgeon Hole" upstream of Orleans, CA (rkm 96). Larvae and juveniles have been caught in the Karuk Tribe's Big Bar trap (rkm 80) on the Klamath and in the Willow Creek trap (rkm 40) on the Trinity River. In the Sacramento River, green sturgeon spawn in late spring and early summer above Hamilton City and perhaps as far upstream as Keswick Dam (CDFG 2002). Green sturgeon spawning has also been documented in the Rogue River (Erickson et al. 2001, Rien et al. 2001, NMFS 2005).

Early Life History: Green sturgeon larvae first feed at 10 days post hatch, and metamorphosis to the juvenile stage is complete at 45 days. Larvae grow fast, reaching a length of 66 mm and a weight of 1.8 g in 3 weeks of exogenous feeding. Juveniles averaged 29 mm at the peak of occurrence in June/July at the Red Bluff Diversion Dam (California) fish trap and 36 mm at their peak abundance in July at the GCID trap (NMFS 2005a). These growth rates are consistent with rapid juvenile growth to 300 mm in 1 year and to over 600 mm within 2 to 3 years in the Klamath River (Nakamoto et al. 1995). Juveniles appear to spend 1 to 3 years in freshwater before they enter the ocean (Nakamoto et al. 1995).

Ocean Residence: Green sturgeon disperses widely in the ocean after their out-migration from freshwater (Moyle et al. 1992). Tagged green sturgeon from the Sacramento and Columbia Rivers are primarily captured to the north in coastal and estuarine waters, with some fish tagged in the Columbia River being recaptured as far north as British Columbia (WDFW 2002a). The pattern of a northern migration is supported by the large concentration of green sturgeon in the Columbia River estuary, Willapa Bay, and Grays Harbor which peaks in August. These fish tend to be immature; however, mature fish and at least one ripe fish have been found in the lower Columbia River (WDFW 2002a). Genetic evidence suggests that Columbia River green sturgeon stocks are a mixture of fish from at least the Sacramento, Klamath, and Rogue Rivers (Israel et al. 2002).

Age and Growth: Green sturgeon is a long-lived, slow-growing species as are all sturgeon species (Nakamoto et al. 1995, Farr et al. 2002). Size-at-age is consistently smaller for fish from the Klamath River (Nakamoto et al. 1995) in comparison to fish from Oregon until around age 25, but thereafter the pattern is reversed. This could be the result of actual differences in growth or in ageing techniques. The asymptotic length for Klamath fish of 218 cm is close to the maximum observed size of 230 cm reported by Moyle et al. (1992), but substantially larger than for fish in Oregon (females 182 cm, males 168 cm).

Feeding: Little is known about green sturgeon feeding other than general information. Adults in the Sacramento-San Joaquin delta feed on benthic invertebrates including shrimp, mollusks, amphipods, and even small fish (Houston 1988; Moyle et al. 1992). Juveniles in the Sacramento River delta feed on opossum shrimp, *Neomysis mercedis*, and *Corophium* amphipods (Radtke 1966). Adams (2002) reported opisthobranch mollusks (*Philline* sp.) were the most common prey for one 100 cm green sturgeon from the Sacramento-San Joaquin estuary.

9A.1.3. Distribution

Green sturgeon is a widely distributed and marine-oriented species found in nearshore waters from Baja California to Canada (NMFS 2008a), but its estuarine/marine distribution and the seasonality of estuarine use range-wide are largely unknown. Southern DPS green sturgeon populations are known to congregate in coastal waters and estuaries, including non-natal estuaries, such as the Rogue River. Beamis and Kynard (1997) suggested that green sturgeon move into estuaries of non-natal rivers to feed. Information from fisheries-dependent sampling suggests that green sturgeon only occupy large estuaries during the summer and early fall in the northwestern U.S.

Green sturgeon are known to enter Washington estuaries during summer (Moser and Lindley 2007). Commercial catches peak in October in the Columbia River estuary, and records from other estuarine fisheries (Willapa Bay and Grays Harbor, Washington) support the idea that sturgeon are only present in these estuaries from June until October (Moser and Lindley 2007). This information suggests that southern DPS green sturgeon are likely to use the Klamath River estuary only during the summer and fall months. As southern DPS sturgeon spend the majority of their life in the ocean, and individuals spend some time in a number of estuaries along the West Coast in the summer and fall, only a small proportion of the southern DPS green sturgeon would be expected to be present in the Klamath River estuary in any given year.

San Francisco Bay and its associated river systems contain the southern-most spawning population of green sturgeon. White sturgeon supports a large fishery in this area, particularly in San Pablo Bay, which has been extensively studied by California Department of Fish and Game (CDFG) since the 1940s. While green sturgeon are not common, they are collected incidentally in a white sturgeon trammel net monitoring program during most years in numbers ranging from 5 to 110 fish. Green sturgeon juveniles are found throughout the Delta and San Francisco Bay.

The Columbia River has supported a large white sturgeon fishery for many years in which green sturgeon are taken as bycatch. In the mid-1930's before Bonneville dam, green sturgeon were found up to the Cascade Rapids. Green sturgeon are presently found up river to the Bonneville Dam (rkm 235), but are predominately found in the lower 60 rkm. Tagging studies indicate a substantial exchange of fish between the Columbia River and Willapa Bay (WDFW 2002). Willapa Bay, along with the Columbia River and Grays Harbor, is one of the estuaries where green sturgeon populations concentrate in summer. Generally, green sturgeon are more abundant than white sturgeon in Willapa Bay (Emmett et al. 1991).

Grays Harbor in Washington is the northernmost estuary where green sturgeon populations concentrate in the summer. Tribal and commercial fisheries for green sturgeon occur in Grays Harbor. Green sturgeon occur sporadically in small numbers throughout coastal Washington (WDFW 2002a) and are routinely encountered in the coastal Washington trawl fishery as minor incidental catch (WDFW 2002b). Green sturgeon are occasionally caught in small coastal bays and estuaries during tribal salmon fisheries.

Green sturgeon occur in small numbers along the western coast of Vancouver Island (Houston 1988) and the Skeena River. Historically, green sturgeon were not uncommon in the Fraser River (EPIC et al. 2001). Since the Fraser River white sturgeon fishery has collapsed; however, green sturgeon are only taken there occasionally.

9A.1.4. Legal Description

NMFS (2006a) published a final rule listing the southern DPS of green sturgeon as threatened in 2006. NMFS (2008) defined two DPSs for green sturgeon – a southern DPS that spawns in the Sacramento River and a northern DPS with spawning populations in the Klamath and Rogue rivers. The southern DPS includes all green surgeon spawning populations south of the Eel

River in California, of which only the Sacramento River currently contains a spawning population. NMFS (2008a) has declared the northern DPS a Species of Concern.

NMFS designated critical habitat for the southern green sturgeon DPS in 2009 (NMFS 2009). NMFS is its critical habitat listing designated the following specific primary constituent elements (PCEs) which are essential for the conservation of the southern green sturgeon DPS in freshwater river systems:

Food resources: abundant prey items for larval, juvenile, sub-adult, and adult life stages.
Substrate: substrates suitable for egg deposition and development, larval development, and sub-adults and adults. Spawning is believed to occur over substrates ranging from clean sand to bedrock, with preferences for cobble (Moyle et al.1995).

Water: a flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages.

Water quality: suitable water quality for normal behavior, growth, and viability of life stages, including temperature, salinity, oxygen content, and other chemical characteristics.

9A.1.5. Species Current Condition

Population size and trends for green sturgeon in the Southern DPS have been estimated by comparing the relative size of the Sacramento-San Joaquin green sturgeon population (Southern DPS) with the Klamath River population (Northern DPS) (Beamesderfer et al. (2005). Using Klamath River tribal fishery harvest rate data and assuming that adults represent 10 percent of the population at equilibrium, the Klamath green sturgeon population (Northern DPS) size is roughly estimated to be approximately 19,000 fish with an annual recruitment of 1,800 age-1 fish (Reclamation, 2008b).

Based on tagging data and visual observations of adults in pools further downstream, Woodbury (2010, as cited in NMFS 2010a estimates a total of 1,500 spawners. Assuming that spawners represent 10 percent of the population, the number of individuals in the Southern DPS would be about 15,000 individuals, or somewhat smaller than the estimate for the Klamath population.

NMFS (2002) has determined that North American green sturgeon is comprised of two populations that are both discrete and significant as defined in the DPS policy. The northern DPS consists of coastal populations ranging from the Eel River northward while the southern DPS includes any coastal or central valley populations south of the Eel River, with the only known population being in the Sacramento River. NMFS (2005a) in its updated status review provided new and updated green sturgeon information on genetic analyses, oceanic distribution and behavior, freshwater distribution, and catch data. This more complete genetic analyses indicates there is a clear split between the southern green sturgeon DPS and the northern green sturgeon DPS.

9A.2. Southern Resident DPS Killer Whale

9A.2.1. Description

Killer whales (*Orcinus orca)* are members of the family Delphinidae, which includes 17-19 genera of marine dolphins (Rice 1998, LeDuc et al. 1999). Systematic classifications based on morphological comparisons have variously placed the genus *Orcinus* in the subfamilies Globicephalinae or Orcininae with other genera such as *Feresa*, *Globicephala*, *Orcaella*, *Peponocephala*, and *Pseudorca* (Wiles 2004). However, recent molecular work suggests that *Orcinus* is most closely related to the Irawaddy dolphin (*Orcaella brevirostris*), with both forming the subfamily Orcininae (LeDuc et al. 1999).

Killer whales are considered the world's largest dolphin. The sexes show considerable size dimorphism, with males attaining maximum lengths and weights of 9.0 m and 5,568 kg, respectively, compared to 7.7 m and 3,810 kg for females (Wiles 2004). Adult males develop larger pectoral flippers, dorsal fins, tail flukes, and girths than females (Clark and Odell 1999 in Wiles 2004). The dorsal fin reaches heights of 1.8 m and is pointed in males, but grows to only 0.7 m and is more curved in females. Killer whales have large paddle-shaped pectoral fins and broad rounded heads with only the hint of a facial beak. The flukes have pointed tips and form a notch at their midpoint on the trailing edge.

Killer whales are easily identifiable by their distinctive black-and-white color pattern, which is among the most striking of all cetaceans. Animals are black dorsally and have a white ventral region extending from the chin and lower face to the belly and anal region (Figure 6-4). The underside of the tail fluke is white or pale gray, and may be thinly edged in black. Several additional white or gray markings occur on the flanks and back. These include a small white oval patch behind and above the eye, a larger area of white connected to the main belly marking and sweeping upward onto the lower rear flank, and a gray or white "saddle" patch usually present behind the dorsal fin (Figure 9A-1).

9A.2.2. Classification in the Northeastern Pacific

Three distinct forms of killer whales- residents, transients, and offshores- are recognized in the northeastern Pacific Ocean. Although there is considerable overlap in their ranges, these forms display significant genetic differences due to a lack of interchange between member animals (Stevens et al. 1989, Hoelzel and Dover 1991, Hoelzel et al. 1998, Barrett- Lennard 2000, Barrett-Lennard and Ellis 2001, Krahn et al. 2004). Important differences in ecology, behavior, morphology, and acoustics also exist (Baird 2000, Ford et al. 2000). These forms are currently applied only to killer whales occurring in this north Pacific Ocean region, but may also be appropriate for some populations off eastern Asia (Krahn et al. 2002).

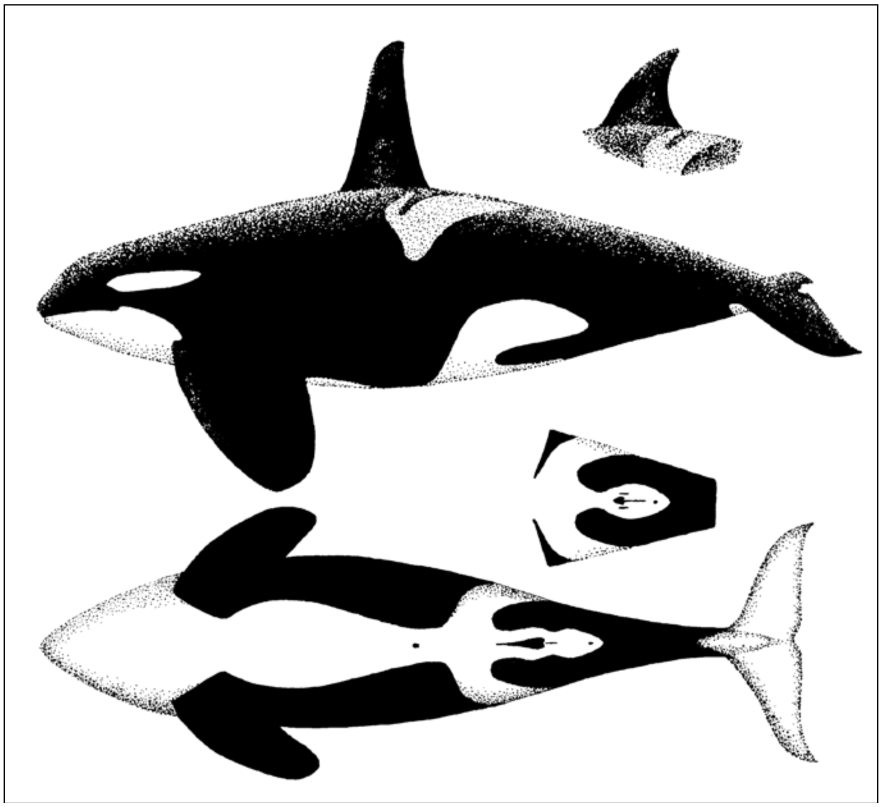


Figure 9A-1. Southern Resident Killer Whale Morphological Characteristics

9A.2.2.1. Resident Killer Whales

In the northeastern Pacific, resident killer whales are recognized in four distinct communities: southern, northern, southern Alaska, and western Alaska (Krahn et al. 2002). Resident killer whales differ from transient and offshore animals by having a dorsal fin that is more curved and rounded at the tip (Ford et al. 2000). Residents also exhibit at least five patterns of saddle patch pigmentation (Baird and Stacey 1988). They feed primarily on fish, occur in large stable pods typically comprised of 10 to about 60 individuals, and also differ in vocalization patterns (Ford 1989, Felleman et al. 1991, Ford et al. 1998, 2000, Saulitis et al. 2000). A fifth resident community, known as the western North Pacific residents, is thought to occur off eastern Russia and perhaps Japan (Krahn et al.2002).

9A.2.2.2. Transient Killer Whales

Transients do not associate with resident and offshore whales despite having a geographic range that is largely sympatric with both forms (Figure 4). Compared to residents, transients occur in smaller groups of usually less than 10 individuals (Ford and Ellis 1999, Baird 2000, Baird and Whitehead 2000), display a more fluid social organization, and have diets consisting largely of other marine mammals (Baird and Dill 1996, Ford et al. 1998, Saulitis et al. 2000). They also move greater distances and tend to have larger home ranges than residents (Goley and Straley 1994, Dahlheim and Heyning 1999, Baird 2000). Morphologically, the dorsal fins of transients are straighter at the tip than in residents and offshores (Ford and Ellis 1999, Ford et al. 2000). Two patterns of saddle pigmentation are recognized (Baird and Stacey 1988). Recent genetic investigations using both nuclear DNA and mtDNA have found significant genetic differences between transients and other killer whale forms, confirming the lack of interbreeding (Stevens

1989, Hoelzel and Dover 1991, Hoelzel et al. 1998, Barrett-Lennard 2000, Barrett-Lennard and Ellis 2001).

These studies also indicate that up to three genetically distinct assemblages of transient killer whales exist in the northeastern Pacific. These are identified as 1) west coast transients, which occur from southern California to southeastern Alaska (Figure 4), 2) Gulf of Alaska transients, and 3) AT1 pod, which inhabits Prince William Sound and the Kenai Fjords in the northern Gulf of Alaska and is highly threatened with just nine whales remaining (Ford and Ellis 1999, Barrett-Lennard 2000, Barrett-Lennard and Ellis 2001). Genetic evidence suggests there is little or no interchange of members among these populations (Barrett-Lennard and Ellis 2001)

9A.2.2.3. Offshore Killer Whales

Due to a scarcity of sightings, much less information is available for the offshore killer whale population, which was first identified in the late 1980's (Ford et al. 1992, 1994, Walters et al 1992. Records are distributed from southern California to Alaska (Figure 4), including many from western Vancouver Island and the Queen Charlotte Islands (Ford and Ellis 1999, Krahn et al. 2002). Recent data from Alaska has extended the population's range to the western Gulf of Alaska and eastern Aleutians (Wiley 2004.).

Offshore killer whales usually occur 15 km or more offshore, but also visit coastal waters and occasionally enter protected inshore waters. Sightings have been made up to 500 km off the Washington coast (Krahn et al. 2002). Animals typically congregate in groups of 20-75 animals and are presumed to feed primarily on fish. Intermixing with residents and transients has not been observed. Genetic analyses indicate that offshore killer whales are reproductively isolated from other forms, but are more closely related to the southern residents (Hoelzel et al 1998, Barrett-Lennard and Ellis 2001). Offshores are thought to be slightly smaller in body size than residents and transients, and have dorsal fins and saddle patches resembling those of residents (Walters et al. 1992, Ford et al. 2000).

9A.2.3. Legal Status

The southern resident killer whale DPS was listed as endangered under the ESA on November 18, 2005 (NMFS 2005b). NMFS (2008b) subsequently published a recovery plan for southern resident killer whales in 2008. The killer whale was also listed as an endangered state of Washington species in June 2004. NMFS determined that the southern resident stock was below its optimum sustainable population and designated it as depleted under the Marine Mammal Protection Act (MMPA) in May 2003 (68 FR 31980) and a Proposed Conservation Plan was announced in 2005 (70 FR 57565).

The National Marine Fisheries Service (NMFS 2006b) designated critical habitat for the southern resident DPS on November 29, 2006. The following physical or biological critical habitat features are identified as essential to this species conservation: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging. NMFS (2006b) identified three "specific areas" within the geographical area occupied by the species, which contain these important physical or biological features: (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca. These critical habitat areas comprise approximately 2,560 square miles of marine habitat within the area occupied by southern Resident DPS killer whales in Washington.

9A.2.4. Life History

Social Organization: Killer whales are highly social animals that occur primarily in groups or pods of up to 40-50 animals (Dahlheim and Heyning 1999, Baird 2000). Mean pod size varies among populations, but often ranges from 2 to 15 animals (Kasuya 1971, Condy et al. 1978, Mikhalev et al. 1981, Braham and Dahlheim 1982, Dahlheim et al. 1982, Baird and Dill 1996). Larger aggregations of up to several hundred individuals occasionally form, but are usually considered temporary groupings of smaller social units that probably congregate near seasonal concentrations of prey, for social interaction, or breeding (Dahlheim and Heyning 1999, Baird 2000, Ford et al. 2000).

Single whales, usually adult males, also occur in many populations (Norris and Prescott 1961, Hoelzel 1993, Baird 1994). Differences in spatial distribution, abundance, and behavior of food resources probably account for much of the variation in group size among killer whale populations. For example, sympatric populations of resident and transient whales in Washington and British Columbia vary substantially in average pod size. Transients forage in small groups on wary and patchily distributed marine mammals and are presumably able to maximize their per capita energy intake through reduced competition over food (Baird and Dill 1996, Ford and Ellis 1999, Baird and Whitehead 2000).

In contrast, the larger groups of resident whales may be better able to detect schools of fish, enabling individual members to increase food consumption (Ford et al. 2000). The age and sex structure of killer whale social groups has been reported for populations at several locations. Olesiuk et al. (1990a) reported that pods in Washington and British Columbia were comprised of 19 percent adult males, 31 percent adult females, and 50 percent immature whales of either sex. In Alaska, 24 percent of the animals in pods were adult males, 47 percent were either adult females or subadult males, and 29 percent were younger animals (Dahlheim 1997, Dahlheim et al. 1997).

For southern oceans, Miyazaki (1989) found that 16 percent of populations were adult males, 8 percent were adult females with calves, and 76 percent were immatures and adult females without calves. At Marion Island in the southern Indian Ocean, 29 percent of the population were adult males, 21 percent were adult females, 8 percent were calves, 25 percent were subadults, and 17 percent unidentified (Condy et al. 1978). Some of the most detailed studies of social structure in killer whales have been made in British Columbia, Washington, and Alaska during the past few decades, with much information available on group size, structure, and stability, and vocal traits (Ford 1989, 1991, Bigg et al. 1990, Matkin et al. 1999b, Ford et al. 2000, Yurk et al. 2002). Social organization in this region is based on maternal kinship and may be characteristic of killer whale populations throughout the world (Ford 2002).

Vocalizations: Vocal communication is particularly advanced in killer whales and is an essential element of the species' complex social structure. Like all dolphins, killer whales produce numerous types of vocalizations that are useful in navigation, communication, and foraging

(Dahlheim and Awbrey 1982, Ford 1989, Barrett-Lennard et al.1996, Ford et al. 2000). Sounds are made by air forced through structures in the nasal passage and are enhanced and directed forward by a fatty enlargement near the top of the head, known as the melon. Most calls consist of both low- and high frequency components (Bain and Dahlheim 1994). The low-frequency component is relatively omnidirectional, with most energy directed forward and to the sides (Schevill and Watkins 1966).

Diving and Swimming Behavior: Respiration rates of killer whales vary with activity level (Ford 1989). Dive cycles in transient whales average 5-8 minutes in total length and usually consist of three to five short dives lasting 10-35 seconds each followed by a longer dive averaging 4-7 minutes (range = 1-17 minutes) (Erickson 1978, Morton 1990, Ford and Ellis 1999). Surface blows following each of the short dives in a cycle last 3-4 seconds. Dive cycles in resident whales follow a similar pattern, but have long dives that are usually much briefer than in transients, averaging about 3 minutes and rarely exceeding 5 minutes (Morton 1990, Ford and Ellis 1999).

Southern residents spend 95 percent of their time underwater, nearly all of which is between the surface and a depth of 30 m (Baird et al. 1998, 2003, Baird 2000). Preliminary information March 2004 14 Washington Department of Fish and Wildlife indicates that up to two dives per hour are made below 30 m. However, these represent fewer than 1 percent of all dives and occupy less than 2.5 percent of an animal’s total dive time. In the vicinity of the San Juan Islands, maximum dive depths averaged 141 m per animal among seven individuals tagged with time-depth recorders in July 2002 (Baird et al. 2003). One juvenile whale twice exceeded 228 m, causing Baird et al. (2003) to speculate that members of this population are probably capable of diving to 350 m, which is the approximate maximum bottom depth of the core inland waters of their summer range. The deepest dive reported for a killer whale is 260 m by a trained animal (Bowers and Henderson 1972).

Killer whales normally swim at speeds of 5-10 km per hour, but can attain maximum speeds of 40 km per hour (Lang 1966, Erickson 1978, Kruse 1991, Williams et al. 2002a). Diving animals reach a velocity of 22 km per hour, or 6 m per second, during descents and ascents. Bursts in speed during dives commonly occur when prey are chased (Baird et al. 2003)

Dispersal/Movements: Killer whale movements are generally thought to be far ranging, but detailed information on year round travel patterns is lacking for virtually all populations (Wiley 2004). Many killer whale populations appear to inhabit relatively well-defined seasonal home ranges linked to locations of favored prey, especially during periods of high prey abundance or vulnerability, such as fish spawning and seal pupping seasons (Jefferson et al. 1991, Reeves et al. 2002). Killer whale occurrence has been tied to migrating rorqual whales off eastern Canada (Sergeant and Fisher 1957), minke whale presence in southern oceans (Mikhalev et al. 1981, Pitman and Ensor 2003), sea lion and elephant seal pupping sites in the southwest Indian Ocean, Argentina, and North Pacific (Tomilin 1957, Norris and Prescott 1961, Condy et al. 1978, Lopez and Lopez 1985, Hoelzel 1991, Baird and Dill 1995), migrating herring (*Clupea harengus*) and other fish in the northeastern Atlantic (Jonsgård and Lyshoel 1970, Bloch and Lockyer 1988, Christensen 1988, Evans 1988, Similä et al. 1996), and returning salmon in the northeastern Pacific (Balcomb et al. 1980, Heimlich-Boran 1986a, 1988, Felleman et al. 1991, Nichol and

Shackleton 1996). Defended territories have not been observed around these or other food sources (Dahlheim and Heyning 1999, Baird 2000).

Annual north-south migrations has not been clearly documented for any killer whale population (Baird 2001), although such movements are suspected among some animals visiting the Antarctic (Mikhalev et al. 1981, Visser 1999a, Pitman and Ensor 2003). Regional movement patterns are probably best known for populations in the northeastern Pacific and may be illustrative of movements occurring in other parts of the world. Both resident and transient killer whales have been recorded year-round in Washington, British Columbia, and Alaska (Heimlich-Boran 1988, Baird and Dill 1995, Olson 1998, Baird 2001). Many pods inhabit relatively small core areas for periods of a few weeks or months, but travel extensively at other times. Known ranges of some individual whales or pods extend from central California to the Queen Charlotte Islands off northern British Columbia (a distance of about 2,200 km) for southern residents, from southern Vancouver Island to southeastern Alaska (about 1,200 km) for northern residents, from southeastern Alaska to Kodiak Island (about 1,450 km) for southern Alaska residents, and from central California to southeastern Alaska (about 2,660 km) for transients (Goley and Straley 1994; Dahlheim and Heyning 1999; Krahn et al. 2002; J. K. B. Ford and G. M. Ellis, unpubl. data).

Both types of whales can swim up to 160 km per day (Erickson 1978, Baird 2000), allowing rapid movements between areas. For example, members of K and L pods once traveled a straight-line distance of about 940 km from the northern Queen Charlotte Islands to Victoria, Vancouver Island, in seven days (J. K. B. Ford and G. M. Ellis, unpubl. data). Other resident pods in Alaska have journeyed 740 km in six days and made a 1,900- km round trip during a 53-day period (Matkin et al. 1997). Transients are believed to travel greater distances and have larger ranges than residents (Goley and Straley 1994, Dahlheim and Heyning 1999, Baird 2000), as reflected by maximum home range estimates of 140,000 km2 for transients and 90,000 km2 for residents suggested by Baird (2000). A linear distance of 2,660 km covered by three transients from Glacier Bay, Alaska, to Monterey Bay, California (Goley and Straley 1994), is the longest recorded movement by the species.

Reproduction: Killer whales are believed to mate in the North Pacific from May to October (Nishiwaki 1972, Olesiuk et al. 1990, Matkin et al. 1997). However, small numbers of conceptions apparently happen year-round, as evidenced by births of calves in all months. Gestation periods in captive killer whales average about 17 months (Asper et al. 1988, Duffield et al. 1995). Mean interval between viable calves is four years (Bain 1990). Newborns measure 2.2 to 2.7 m long and weigh about 200 kg (Nishiwaki and Handa 1958, Olesiuk et al. 1990, Clark et al. 2000, Ford 2002). Calves remain close to their mothers during their first year of life, often swimming slightly behind and to the side of the mother's dorsal fin. Weaning age remains unknown, but nursing probably ends at 1 to 2 years of age (Kastelein et al. 2003). Mothers and offspring maintain highly stable social bonds throughout their lives and this natal relationship is the basis for the matrilineal social structure (Bigg et al. 1990, Baird 2000, Ford et al. 2000).

9A.2.5. Life Cycle Needs

Killer whales frequent a variety of marine habitats with adequate prey resources and do not appear to be constrained by water depth, temperature, or salinity (Baird 2000). Although the species occurs widely as a pelagic inhabitant of open ocean, many populations spend large amounts of time in shallower coastal and inland marine waters, foraging even in inter-tidal areas in just a few meters of water. Killer whales tolerate a range of water temperatures, occurring from warm tropical seas to polar regions with ice floes and near freezing waters. Brackish waters and rivers are also occasionally entered (Scheffer and Slipp 1948, Tomilin 1957). Individual knowledge of productive feeding areas and other special habitats (e.g., beach rubbing sites in the Johnstone Strait) is probably an important determinant in the selection of locations visited and is likely a learned tradition passed from one generation to the next (Ford et al. 1998).

Resident and transient killer whales exhibit somewhat different patterns of habitat use while in protected inland waters, where most observations are made (Heimlich-Boran 1988, Morton 1990, Felleman et al. 1991, Baird and Dill 1995). Residents generally spend more time in deeper water and only occasionally enter water less than 5 m deep (Heimlich-Boran 1988, Baird 2000, 2001). Distribution is strongly associated with areas of greater salmon abundance (Heimlich-Boran 1986a, 1988, Felleman et al. 1991, Nichol and Shackleton 1996), but research to date has yielded conflicting information on preferred foraging habitats. Several studies have reported that southern residents feed heavily in areas characterized by high-relief underwater topography, such as subsurface canyons, seamounts, ridges, and steep slopes (Heimlich-Boran 1988, Felleman et al. 1991). Such features may limit fish movements, thereby resulting in greater prey availability, and be used by the whales as underwater barriers to assist in herding fish (Heimlich-Boran 1988).

As top-level predators, killer whales feed on a variety of marine organisms ranging from fish to squid to other marine mammal species. Chinook salmon reportedly comprise over 71 percent of the identified salmonids taken by killer whales (Ford and Ellis 2006). In particular, Ford and Ellis (2006) and Hanson et al. (2010) found that Chinook salmon comprise at least 84 percent of the diet of southern Resident killer whales (southern Residents) while the whales are in the Puget Sound/Juan de Fuca area. Southern resident killer whale survival and fecundity are correlated with Chinook salmon abundance, further indicating a Chinook salmon dietary preference (Ward et al. 2009, Ford et al. 2009). Ford and Ellis (2006) indicated that coastal killer whale populations also consume other salmonids in smaller proportions, including chum (*O. keta*, 22 percent of the diet) pink (*O. gorbuscha*, 3 percent), coho (*O. kisutch*, 2 percent), and sockeye (*O. nerka*, less than 1 percent) salmon, and steelhead (*O. mykiss*, less than 1 percent). Chemical analyses of killer whale fatty acids and contaminant ratios are also consistent with a salmon diet in killer whales (OCAP BA, 2008). The primary prey at greater depths may be Chinook salmon, which swim at depths averaging 25-80 m and extending down to 300-400 m (Candy and Quinn 1999). Other salmonids mostly inhabit the upper 30 m of the water column (Quinn and terHart 1987, Quinn et al. 1989, Ruggerone et al. 1990).

As discussed in the coho salmon effects analysis, the Proposed Action's effects on the hydrology of the Klamath River are concentrated in the reaches immediately downstream of Iron Gate Dam (IGD), with those effects decreasing as the distance from IGD increases. Unlike coho salmon, Chinook salmon primarily spawn within the main stem of the Klamath River and in the channels of the larger tributaries of the Klamath River. That portion of the Chinook salmon population that spawns and rear in the main stem of the Klamath River immediately downstream of IGD is the population segment that has the greatest potential effect from implementing the Proposed

Action. No estimates are available for the numbers of Chinook salmon spawning immediately downstream of IGD. However, natural spawning is known to occur throughout the basin and spawning is not concentrated in the reaches immediately downstream of IGD. The potential effect of implementing the Proposed Action to that fraction of the Chinook salmon population in the reaches closest to IGD are most likely small and not measureable. Thus, with the implementation of the Proposed Action, the potential reduction in the available prey for Orca in the marine environment are insignificant, or discountable.

Hoelzel (1993) has reported no correlation between the feeding behavior of southern Resident killer whales and bottom topography, and found that most foraging took place over deep open water (41 percent of sightings), shallow slopes (32 percent), and deep slopes (19 percent). Ford et al. (1998) described residents as frequently foraging within 50-100 m of shore and using steep nearshore topography to corral fish. Both of these studies, plus those of Baird et al. (1998, 2003), have reported that most feeding and diving activity occurs in the upper 30 m of the water column, where most salmon are distributed (Stasko et al. 1976, Quinn and terHart 1987, Quinn et al. 1989, Ruggerone et al. 1990, Olson and Quinn 1993, Nichol and Shackleton 1996, Candy and Quinn 1999, Baird 2000). Additionally, Chinook salmon occupy nearshore habitats more so than other salmonids (Stasko et al. 1976, Quinn et al. 1989). Reasons for the discrepancies between studies are unclear, but may result from interpod variation and differences in study methodology (Nichol and Shackleton 1996, Baird 2001). Other behaviors, such as resting and socializing are performed in open water with varied bathymetry (Heimlich-Boran 1988, Felleman et al.1991). Habitat use patterns are poorly understood for southern resident pods visiting the outer coast.

9A.2.6. Distribution

The southern Resident DPS killer whales consist of three pods, identified as J, K, and L pods. All three pods reside for part of the year in the inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound), principally during the late spring, summer, and fall (Heimlich-Boran 1988, Felleman et al. 1991, Olson 1998, Osborne 1999, Ford et al. 2000, Krahn et al. 2002). Pods visit coastal sites off Washington and Vancouver Island (Ford et al. 2000), but travel as far south as central California and as far north as the Queen Charlotte Islands. Offshore movements and distribution are largely unknown for the southern Resident DPS killer whale.

9A.2.7. Species Current Condition

The southern Resident killer whale population and its current status are shown from 1974 – 2007 in Table 6-1. The population has reportedly declined to essentially the same size that was estimated during the early 1960s, when it was considered likely depleted (Olesiuk et al. 1990). Since 1974, J and K pods have increased in sizes by 60 percent (mean of 1.9 percent per year) and 38 percent (mean of 1.2 percent per year), respectively. The largest pod, L pod, has grown 28.6 percent (mean of 0.9 percent per year) during this same period, but most recently experienced a 10-year decline from 1994 to 2003 that threatened to reduce the pod’s size below any previously recorded level. Data from 2002 to 2006 indicates that L pod’s decline may have finally ended; however, this slight upward population trend in recent years is not conclusive (NMFS 2008b).

Table 9A-1. Southern Resident killer whale population and pod sizes in Washington and British Columbia, 1974-2007.[a]

Year	J POD	K POD	L POD	TOTAL
1974	15	16	39	70
1975	15	15	41	71
1976	16	14	40	70
1977	18	15	46	79
1978	18	15	46	79
1979	19	15	47	81
1980	19	15	49	83
1981	19	15	47	81
1982	19	14	45	78
1983	19	14	43	76
1984	17	14	43	74
1985	18	14	45	77
1986	17	16	48	81
1987	18	17	49	84
1988	19	18	48	85
1989	18	17	50	85
1990	18	18	53	89
1991	20	17	55	92
1992	19	16	56	91
1993	21	17	59	97
1994	20	19	57	96
1995	22	18	58	98
1996	22	19	56	97
1997	21	19	52	92
1998	22	18	49	89
1999	20	17	48	85
2000	19	17	47	83
2001	20	18	43	81
2002	20	19	44	83
2003	22	20	42	84
2004	23	21	44	88
2005	24	20	44	88
2006	24	22	44	90
2007	25	19	43	87

[a]Source: NMFS 2008b.

9A.3. Other Species

9A.3.1. Southern DPS Pacific Eulachon

9A.3.1.1. Species Description

Eulachon *Thaleichthys Pacificus* (commonly called smelt, candlefish, or hooligan) are a small, anadromous fish from the eastern Pacific eulachon are a short-lived, high-fecundity, high-mortality forage fish, and tend to have extremely large population sizes. NMFS (2012c) describes the following distinguishing physical features: large canine teeth on the vomer (bone in the roof of the mouth) and 18 to 23 rays in the anal fin; sickle-shaped adipose fin; fins have well-developed breeding tubercles (raised tissue "bumps") in ripe males, but these are poorly developed or absent in females; adult coloration is brown to blue on the back and top of the head, lighter to silvery white on the sides, and white on the ventral surface; speckling is fine, sparse, and restricted to the back. Eulachon feed on plankton only while at sea.

9A.3.1.2. Legal Status

NMFS listed the southern DPS Pacfic eulachon as threatened under the ESA on March 18, 2010 (75 FR 13012). This DPS encompasses all populations within the states of Washington, Oregon, and California and extends from the Skeena River in British Columbia (inclusive) south to the Mad River in Northern California (inclusive). The DPS is divided into four sub-areas: Klamath River, Columbia River, Fraser River, and British Columbia coastal rivers south of the Nass River.

NMFS proposed to designate approximately 470.2 km (291.1 mi) of riverine and estuary habitat in California, Oregon, and Washington within the geographical area occupied by the southern DPS Pacific eulachon as critical habitat (NMFS 2010d). NMFS in 2011 designated final critical habitat for eulachon based upon areas which contain one or more physical or biological features essential to the conservation of the species that may require special management considerations or protection (NMFS 2011b).. NMFS (2011b) has designated final critical habitat for 10.7 miles of the Klamath River from the mouth upstream to the confluence with Omogar Creek..

9A.3.1.3. Life History

Eulachon typically spend three to five years in saltwater before returning to fresh water to spawn. Eulachon generally spawn in rivers that are either glacier or snow packed fed and that experience spring freshets. Spawning grounds are typically in the lower reaches of larger rivers (Hay and McCarter 2000). Spawning typically occurs at night. Spawning occurs at between 0 to 10°C throughout the range of the species, and is largely limited to the part of the river that is tidally influenced (Lewis et al. 2002).

Spawning cues and entry into rivers appear to be related to water temperature and the occurrence of high tides (Ricker et al. 1954, Smith and Saalfeld 1955, Spangler 2002) in January, February, and March in the northern part of the DPS, and later in the spring in the southern parts of the DPS. Most eulachon adults die after spawning. Eulachon broadcast their eggs which are fertilized in the water column, sink, and adhere to the river bottom typically in areas of gravel and coarse sand. It has been argued that because freshets rapidly move eulachon eggs and larvae to estuaries, it is likely that eulachon imprint and home to an estuary into which several rivers drain rather than to individual spawning rivers (Hay and McCarter 2000). Eulachon eggs hatch in 20 to 40 days. Newly hatched young, transparent and 4 to 7 mm in length, are carried to the sea with the current (Hay and McCarter 2000).

Juvenile eulachon enter the ocean once they move from shallow nearshore areas to deeper areas over the continental shelf. Larvae and young juveniles become widely distributed in coastal waters, where they are typically found near the ocean bottom in waters 20 to150 m deep (66 to 292 ft) (Hay and McCarter 2000) and sometimes as deep as 182 m (597 ft) (Barraclough 1964). There is currently little information available about eulachon movements in nearshore marine areas and the open ocean. However, eulachon occur as bycatch in the pink shrimp fishery (Hay et al. 1999, Olsen et al. 2000, NWFSC 2008, Hannah and Jones 2009), which indicates that the distribution of these organisms overlaps in the ocean. Adult Pacific eulachon have been recorded from several locations on the Washington and Oregon coasts, and were previously common in Oregon's Umpqua River, and the Klamath River in northern California (Hay and McCarter 2000, Willson et al. 2006, NMFS 2010b).

9A.3.1.4. Species Current Condition

There are few direct estimates of abundance available for eulachon, and there is an absence of monitoring programs in the United States. Most population data comes from fishery catch and landing records, which when combined with anecdotal information, indicate eulachon historically were present in large annual runs and that significant declines in abundance have occurred (Reclamation 2011). The Columbia River, estimated to have historically represented fully half of the taxon's abundance, experienced a sudden decline in its commercial eulachon fishery landings in 1993–1994 (Washington Department of Fish and Wildlife [WDFW] and ODFW 2001, JCRMS 2007). Similar declines in abundance have occurred in the Fraser River and other coastal British Columbia rivers (Hay and McCarter 2000, Moody 2008). In the Klamath River and the Umpqua River, eulachon were once abundant, but have declined to the point where detecting them has become difficult (NMFS 2010b).

There has been no long-term monitoring program targeting eulachon in California, making estimates of historical abundance and abundance trends difficult to generate (Gustafson et al. 2008).